The Electrochemical Society . . .

113th Meeting

NEW YORK
April 27, 28, 29, 30,
May 1, 1958

LOCAL COMMITTEE

General Chairman
F. A. LOWENHEIM

Vice-Chairman
H. R. COPSON

Hotel
A. C. LOONAM

Finance
L. I. GILBERTSON

Registration
M. F. QUAELY

Publicity
C. V. KING and J. L. EVERHART

Ladies
FRANCES LANG

Appears in March Jl.

New York Program

THE ELECTROCHEMICAL SOCIETY

One Hundred and Thirteenth Meeting

April 27, 28, 29, 30, May 1, 1958
Sunday through Thursday

CONDENSED TECHNICAL PROGRAM

Monday, April 28, 1958

Electric Insulation (Abs. 1-8) 9:30-11:30 A.M.; 2:00-4:00 P.M. (Hartford Room, Mezzanine)
Electronics-Semiconductors (Abs. 40-51) 9:30 A.M.-12:15 P.M.; 2:00-4:45 P.M. (Penn Top, 18th floor)
Electrothermics and Metallurgy (Abs. 77-81) 9:30 A.M.-12:00 M.; (Skytop, 18th floor)
Electrothermics and Metallurgy—Corrosion (Abs. 82-87) 1:30-4:30 P.M. (Skytop, 18th floor)
Industrial Electrolytic (Abs. 120-124) 10:00-11:00 A.M.; 2:00-3:30 P.M. (Washington Room, Mezzanine)
Theoretical Electrochemistry (Abs. 125-132) 9:30-11:50 A.M.; 2:00-4:50 P.M. (Gold Ballroom, Mezzanine)
Richards Memorial Lecture 5:00 P.M. (Penn Top, 18th floor)

Tuesday, April 29, 1958

Electric Insulation (Abs. 9-13) 9:00-11:30 A.M.; 2:00-4:00 P.M. (Hartford Room, Mezzanine)
Electronics-Luminescence (Abs. 20-31) 9:00-11:30 A.M.; 2:00-4:55 P.M. (Washington Room, Mezzanine)
Electronics-Semiconductors (Abs. 52-63) 9:00-11:45 A.M.; 2:00-5:00 P.M. (Penn Top, 18th floor)
Electrothermics and Metallurgy (Abs. 88-99) 9:00 A.M.-12:00 M.; 2:00-5:00 P.M. (Skytop, 18th floor)
Theoretical Electrochemistry (Abs. 133-142) 9:00-11:40 A.M.; 2:00-4:45 P.M. (Gold Ballroom, Mezzanine)

Wednesday, April 30, 1958

Electric Insulation (Abs. 14-19) 9:00 A.M.-12:00 M.; 2:00-5:00 P.M. (Hartford Room, Mezzanine)

Electronics-Luminescence (Abs. 32-39) 9:00 A.M.-12:00 M.; 2:00-4:30 P.M. (Washington Room, Mezzanine)

Electronics-Semiconductors (Abs. 64-76) 9:00 A.M.-12:00 M.; 2:00-5:00 P.M. (Penn Top, 18th floor)

Electrothermics and Metallurgy (Abs. 100-107) 9:00-11:00 A.M.; 2:00-4:00 P.M. (Skytop, 18th floor)

Theoretical Electrochemistry (Abs. 143-151) 9:00-11:20 A.M.; 2:00-4:50 P.M. (West Room, Mezzanine)

Thursday, May 1, 1958

Electrothermics and Metallurgy—Electronics-Semiconductors (Abs. 108-119) 9:00 A.M.-12:00 M.; 2:00-5:00 P.M. (Penn Top, 18th floor)

Theoretical Electrochemistry (Abs. 152-156) 9:00 A.M.-12:00 M (Skytop, 18th floor)

GENERAL INFORMATION

Convention Headquarters will be at the Hotel Statler, 7th Ave. and 33rd St., New York 1, N. Y.

Rates per day for rooms (with bath) are: single room $8.00, 9.00, 10.00, 11.00, 12.00, 13.00, 14.00; double-bed room $11.00, 12.00, 13.00, 14.00, 15.00, 16.00, 17.00, 18.00; twin-bed room, $15.00, 16.00, 17.00, 18.00, 19.00, 20.00, 21.00, 22.00; suite-living room, bed room, and bath $36.00, 37.00.

Requests for room reservations at the Headquarters Hotel should be mailed to the Front Office Manager, Hotel Statler, 7th Ave. and 33rd St., New York 1, N. Y. BE SURE to state your intention to attend The Electrochemical Society meeting.

Other hotels within a few blocks of the Headquarters Hotel and their minimum rates are:

Hotel Governor Clinton, 7th Ave. at 31st St., single room $9.00 and up; double-bed room from $14.00; twin-bed room from $15.00.

Hotel New Yorker, 8th Ave. at 34th St., single room $8.00 and up; double-bed room from $11.50; twin-bed room from $14.50.

Sheraton-McAlpin Hotel, Broadway at 34th St., single room starts at $8.35; double-bed or twin-bed room from $12.35.

Sloane House, YMCA, 356 W. 34th St., single room starts at $2.20, double room from $3.40.

Requests for room reservations should include mention of The Electrochemical Society.

The Office of the Secretary will be in the Hudson Room on the Mezzanine Floor.

The Local Committee Office will be in the Sutton Room on the Mezzanine Floor.

Ladies' Headquarters will be in the Boston Room on the Mezzanine Floor.

All technical sessions will be held on either the Mezzanine or 18th floor.

REGISTRATION

The registration desk will be in the Writing Lounge, Mezzanine Floor, except on Thursday when it will be in Penn Top Foyer (18th floor). Following is the registration schedule:

Sunday, April 27—3:00 to 9:00 P.M.
Monday, April 28—8:00 A.M. to 4:00 P.M.
Tuesday, April 29—8:00 A.M. to 4:00 P.M.
Wednesday, April 30—8:30 A.M. to 4:30 P.M.
Thursday, May 1—8:30 A.M. to 12:00 M.

Registration fees are:

Members	$ 8.00
Ladies	5.00
Nonmembers	14.00*
Thursday only	5.00
Students	2.00

*If a nonmember fills out an application blank and is subsequently elected to membership in the Society, the difference between the nonmember and member registration fee will be applied to his first year's dues.

INFORMATION ABOUT NEW YORK

The Hotel Statler is centrally located for all activities. Information about places of interest, theatrical and other attractions, restaurants, and night clubs will be available at the registration desk, or you can write to the New York Visitors Bureau, 90 E. 42 St., New York, N.Y.

SYMPOSIA AND ROUND TABLES

The Electric Insulation Division has scheduled symposia on Ceramics, Plastic Insulation, including a round-table discussion; Chemical Aspects of Printed Wiring, including a round-table discussion.

The Electronics Division-Luminescence Group has scheduled four sessions.

The Electronics Division—Semiconductor Group has scheduled symposia on Semiconductor Materials Research, Transport Phenomena, Diffusion, Physics and Chemistry of Semiconductor Surfaces, and Process Technology. The group has scheduled a joint symposium with the **Electrothermics and Metallurgy Division** on Preparation, Evaluation, and Uses of High Purity Metals on Thursday, May 1.

The Electrothermics and Metallurgy Division has scheduled symposia on Stress Corrosion Cracking of Stainless Steels jointly with the **Corrosion Division** Monday afternoon; Preparation, Evaluation, and Uses of High Purity Metals Monday morning, all day Tuesday, and jointly with the **Electronics Division, Semiconductor Group** all day Thursday; and an all-day Wednesday symposium on High Temperature Property Measurements.

The Industrial Electrolytic Division has scheduled a symposium on Fused Salt Electrolysis and another general session.

The Theoretical Electrochemistry Division has scheduled a symposium on Electrokinetic and Membrane Phenomena all day Monday and Tuesday, with a general session starting Tuesday afternoon, continuing through Thursday morning.

GENERAL FUNCTIONS

Symposia Chairmen Breakfasts

On **Monday, Tuesday, Wednesday,** and **Thursday,** April 28, 29, 30, and May 1, special breakfasts for symposia chairmen will be held. On the day on which he presides at a symposium, each chairman should be at the Office of the Secretary (Hudson Room) *by 7:45 A.M.*

Richards Memorial Lecture
Monday, April 28, 5:00 P.M.

Dr. Abner Brenner, of the National Bureau of Standards, Washington, D.C., will deliver the Richards Memorial Lecture at 5:00 P.M. on Monday, April 28, in the Penn Top (18th floor). He will speak on "Electrolysis of Nonaqueous Solutions."

Monday Evening

On Monday, April 28, all those registered at the meeting are invited to attend the get-acquainted mixer in the Gold Ballroom, Mezzanine Floor, from 8:00 P.M. on. Beer, soft drinks, and snacks will be served on a complimentary basis; a bar will be available for the purchase of other beverages.

Admission is by registration badge. This will be a good opportunity to meet old friends, make new ones, and plan your convention activities.

Tuesday Society Luncheon

The Electrochemical Society Luncheon and Business Meeting will be held on Tuesday, April 29, at 12:15 P.M. in the Penn Top North (18th floor). An outstanding speaker will be featured.

Tuesday Evening Reception and Banquet

A reception for President and Mrs. Norman Hackerman will be held at 6:30 P.M. on Tuesday, April 29, in the Penn Top North (18th floor). Cocktails will be served from 6:30 to 7:30 P.M., followed by dinner at 7:30 P.M. in Penn Top South (18th floor). President Hackerman will deliver the Presidential Address. (Dress optional.)

Wednesday Electronics Division Cocktail Mixer

The Electronics Division will hold a Cocktail Mixer from 5:15 to 6:30 P. M. on Wednesday, April 30, in the Washington Room (Mezzanine Floor).

LADIES' PROGRAM

Ladies' Headquarters will be in the Boston Room, Mezzanine Floor, throughout the meeting. A member

of the Ladies' Committee will be in the Ladies' Headquarters on Sunday from 3:00 to 9:00 P.M. to welcome and assist the ladies in every way.

Monday morning, April 28—From 9:00 to 10:30 A.M. coffee and rolls will be served in the Boston Room (complimentary).

Monday noon, April 28—Luncheon at the Plaza at 12:30 P.M. (complimentary). Gather at Ladies' Headquarters (Boston Room) at 12:00 M. During the afternoon there will be guided shopping tours.

Monday evening, April 28—The ladies are invited to attend the Mixer at 8:00 P.M. in the Gold Ballroom (*see* general program).

Tuesday morning, April 29—From 9:00 to 10:30 A.M. coffee and rolls will be served in the Boston Room (complimentary).

Tuesday noon, April 29—The ladies are invited to attend the Society Luncheon at 12:15 P.M. in the Penn Top North (18th floor). Tickets should be purchased at the registration desk. Tuesday afternoon is open.

Tuesday evening, April 29—The ladies are invited to attend the Reception and Banquet at 6:30 P.M. in the Penn Top (18th floor). Tickets should be purchased at the registration desk.

Wednesday morning and afternoon, April 30—From 9:00 to 10:30 A.M. coffee and rolls will be served in the Boston Room (complimentary). At 11:30 A.M. the ladies will gather in the Boston Room for a yacht cruise around Manhattan Island; sandwiches and coffee will be served (cruise and refreshments complimentary). The cruise will be followed by a visit to the observatory of the Empire State Building which commands an excellent view of New York City. Transportation involved will be an individual responsibility; otherwise these functions are complimentary. Return to the Hotel Statler will be about 5:00 P.M.

Wednesday evening, April 29—Open.

Thursday, May 1—Open for individual arrangements. Guides will be available to suit varied requirements.

LUNCHEONS AND BUSINESS MEETINGS OF DIVISIONS

Electric Insulation Division Luncheon and Business Meeting, Monday, April 28, at 12:15 P.M. in the Buffalo Room (Mezzanine).

Industrial Electrolytic Division Luncheon and Business Meeting, Monday, April 28, at 12:15 P.M. in Penn Top North (18th floor).

Electronics Division Business Meeting at 5:00 P.M. on Tuesday, April 29, in the Washington Room (Mezzanine).

Theoretical Electrochemistry Business Meeting, Wednesday, April 30, at 11:20 A.M. in Penn Top North (18th floor).

Electrothermics and Metallurgy Luncheon and Business Meeting, Wednesday, April 30, at 12:15 P.M. in the Buffalo Room (Mezzanine).

BOARD AND COMMITTEE MEETINGS

Sunday, April 27, 2:00 P.M.—Meeting of the **Board of Directors** in the Buffalo Room (Mezzanine).

Sunday, April 27, 7:30 P.M.—Meeting of the **Investment Advisory Panel** in the Schuyler Room (18th Floor).

Tuesday, April 29, 5:00 P.M.—Meeting of the **Editorial Staff** of the JOURNAL in the Hudson Room (Mezzanine).

Tuesday, April 29, 5:00 P.M.—Meeting of the **Membership Committee** in the Schuyler Room (18th floor).

Wednesday, April 30, 5:00 P.M.—Meeting of the **Council of Local Sections** in the Schuyler Room (18th floor).

Thursday, May 1, 12:00 M.—Meeting of **General Chairmen of Future Meetings.** Meet at the Office of the Secretary (Hudson Room) at 12:00 M. Luncheon will be arranged.

COST OF VARIOUS FUNCTIONS

(other than registration)

Please buy tickets as early as possible.

Symposia Chairmen breakfasts
Standard menu prices

Division Luncheon	$ 4.25
Society Luncheon	4.75

Monday Evening Mixer
Complimentary
Tuesday Reception and Banquet
Single ..... $ 9.00
Couple 16.00
Wednesday Electronics Division
Cocktail Mixer 3.00

Ladies' Functions
Coffee and rolls, Monday, Tuesday, Wednesday. Complimentary
Monday luncheon at the Plaza
Complimentary
Monday Evening Mixer
Complimentary
Tuesday Society Luncheon.. $4.75
Tuesday Reception and Banquet
Couple $16.00
Wednesday Yacht trip and Empire State Building visit
Complimentary
(except for transportation to and from hotel)

JOURNALS

Copies of the January, February, March, and April issues of the "Journal of The Electrochemical Society" will be available at the registration desk. The price of a single copy of the JOURNAL is $1.25 to members and $1.75 to nonmembers of the Society.

EXTENDED ABSTRACTS

The Electronics Division Extended Abstracts booklet should be available about April 15, 1958 from Martin F. Quaely, Research Dept., Lamp Div., Westinghouse Electric Corp., Bloomfield, N.J., at the price of $2.50. Copies will also be on sale at the registration desk at the New York Meeting.

MESSAGES

Members and guests attending the meeting should check occasionally at the bulletin board near the registration desk to see if there are messages for them. Phone calls received in Society Headquarters Office will be posted on the bulletin board.

DISCUSSION

No recordings will be made of oral discussions. Those contributing to the discussion of a paper and desiring their remarks to be published will be supplied by the symposium chairman with a printed form on which

any discussion may be written. These forms should be given to the Secretary-Treasurer of the Division or to the Managing Editor of the JOURNAL after the session; they can be mailed to the Managing Editor of the JOURNAL, 1860 Broadway, New York 23, N.Y. The discussion will then be referred to the author for reply. Publication of the discussion and the comments of the author depends on publication of the article in the JOURNAL.

Written discussion should be submitted within two months following publication of the article in the JOURNAL. A Discussion Section is published semiannually in the JOURNAL.

EMPLOYMENT POSTERS

Companies which desire to recruit employees at the New York Meeting will have posters to this effect on a bulletin board near the registration desk.

Technical Program

Monday, April 28, 1958

9:00 A.M.—Formal opening of the 113th Meeting with Introduction by General Chairman Frederick A. Lowenheim and Response by President Norman Hackerman in Penn Top (18th floor).

ELECTRIC INSULATION

Monday, April 28, 1958

Ceramics
with L. J. Frisco presiding
(HARTFORD ROOM)

9:30 A.M.—"Effect of Temperature and Thickness on the Electrical Resistivity of Ceramic Coatings" by W. H. Fischer (Abstract No. 1)

10:00 A.M.—"High Temperature Aluminum Oxide Insulation for Wire and Strips" by Henry Walker (Abstract No. 2)

10:30 A.M.—"Progress in High Frequency Ceramic Dielectric Insulation" by E. J. Smoke and S. DiVita (Abstract No. 3)

11:00 A.M.—"Ultra Low Loss, High Frequency Dielectric Insulators" by E. J. Smoke and S. DiVita (Abstract No. 4)

12:15 P.M.—Electric Insulation Division Luncheon and Business Meeting in the Buffalo Room (Mezzanine). Guest Speaker, H. H. Chapman, Jr., Owens-Corning Fiberglas Corp., New York, N.Y.

Electric Insulation (cont'd)
Monday, April 28, 1958
Ceramics
with Hans Thurnauer presiding
(HARTFORD ROOM)

2:00 P.M.—"Boron Nitride, a Machinable High Temperature Insulation Material" by J. J. McGahan (Abstract No. 5)

2:30 P.M.—"The Effect of the Crystalline and Glassy Phases on the Dielectric Properties of Ceramic High Frequency Insulation" by B. R. Eichbaum (Abstract No. 6)

3:00 P.M.—"Some Current Problems in the Production of Magnetic Ceramics" by George Economos (Abstract No. 7)

3:30 P.M.—"D.T.A. Characteristics of Barium Titanate" by K. G. Skinner (Abstract No. 8)

5:00 P.M.—Richards Memorial Lecture—"Electrolysis of Nonaqueous Solutions" by A. Brenner (Penn Top)

Electric Insulation (cont'd)
Tuesday, April 29, 1958
Plastic Insulation
with A. J. Sherburne presiding
(HARTFORD ROOM)

9:00 A.M.—"Flammability Testing of Plastics" by L. V. Larsen (Abstract No. 9)

9:30 A.M.—"Damage to Plastic Insulation Caused by Heavy Forming Die Pressures" by F. H. Wells and J. H. Whitley (Abstract No. 10)

10:00 A.M.—"Flashover Strength of Plastics" by L. J. Frisco and J. J. Chapman (Abstract No. 11)

10:30 A.M.—"Results of Reinforced and Laminated Plastics Survey" by L. R. Samelson (Abstract No. 12)

11:00 A.M.—"LEXAN Polycarbonate Resin" by G. C. Calderwood (Abstract No. 13)

12:15 P.M.—The Electrochemical Society Luncheon and Business Meeting in the Penn Top North (18th floor)

MEETING ROOM SCHEDULES

Meeting	Monday		Tuesday		Wednesday		Thursday	
	A.M.	P.M.	A.M.	P.M.	A.M.	P.M.	A.M.	P.M.
Electric Insulation	B	B	B	B	B	B		
Electronics—Luminescence			A	A	A	A		
Electronics—Semiconductors	C	C	C	C	C	C		
Electrothermics and Metallurgy—Semiconductors							C	C
Electrothermics and Metallurgy—Corrosion		E						
Electrothermics and Metallurgy	E		E	E	E	E		
Industrial Electrolytics	A	A						
Theoretical Electrochemistry	F	F	F	F	D	D	E	

A = Washington Room (Mezzanine)
B = Hartford Room (Mezzanine)
C = Penn Top (18th floor)
D = West Room (Mezzanine)
E = Skytop (18th floor)
F = Gold Ballroom (Mezzanine)

Electric Insulation (cont'd)

Tuesday, April 29, 1958

Plastic Insulation
with A. J. Sherburne presiding
(HARTFORD ROOM)

2:00 P.M.—Round-table discussion of the Recent Developments and Problems Associated with the Use of Plastic Insulation at High Temperatures.

Electric Insulation (cont'd)

Wednesday, April 30, 1958

Chemical Aspects of Printed Wiring
with E. J. Lorenz presiding
(HARTFORD ROOM)

9:00 A.M.—"Processing Effects on High Pressure Thermosetting Laminates Used in the Manufacture of Printed Wiring Boards" by St. John Bain (Abstract No. 14)
9:45 A.M.—"Environmental Conditioning" by Elmer Varga (Abstract No. 15)
10:45 A.M.—"Organic Coatings in Printed Wiring" by B. G. Brand (Abstract No. 16)
11:30 A.M.—"Etching Control" by D. Alnutt (Abstract No. 17)

Electric Insulation (cont'd)

Wednesday, April 30, 1958

Chemical Aspects of Printed Wiring
with E. J. Lorenz presiding
(HARTFORD ROOM)

2:00 P.M.—"Plating Considerations for Printed Wiring" by W. H. Hannahs (Abstract No. 18)
2:40 P.M.—"Improved High Temperature Resistance of Copper Clad Teflon-Fiberglas Laminate" by A. H. Haroldson (Abstract No. 19)
3:30 P.M.—Round-table discussion on Printed Wiring

ELECTRONICS—LUMINESCENCE

Tuesday, April 29, 1958
with H. C. Froelich presiding
(WASHINGTON ROOM)

9:00 A.M.—Keynote Address—"Use of Polarized Light in the Study of Luminescent Systems" by C. C. Klick (Abstract No. 20)
9:45 A.M.—"Effect of Impurities on

the Plaque Brightness of a 3000°K Calcium Halophosphate Phosphor" by A. Wachtel (Abstract No. 21)

10:10 A.M.—"The System ZnO.CdO.-B_2O_3, Phase Relationships and Fluorescence" by D. E. Harrison and F. A. Hummel (Abstract No. 22)

10:35 A.M.—"Phase Equilibria in the System ZnO-P_2O_5" by F. L. Katnack and F. A. Hummel (Abstract No. 23)

11:00 A.M.—"Phosphors in the System Magnesia-Cadmium Oxide-Zinc Oxide-Silica" by P. G. Herold (Abstract No. 24)

12:15 P.M.—The Electrochemical Society Luncheon and Business Meeting in the Penn Top North (18th floor)

Electronics—Luminescence (cont'd)

Tuesday, April 29, 1958
with C. W. Jerome presiding
(WASHINGTON ROOM)

2:00 P.M.—"Some Observations on Aluminum Nitride" by C. Buhrer and E. Banks (Abstract No. 25)

2:25 P.M.—"Applications of Luminescence in Glass" by R. J. Ginther, J. H. Schulman, and G. W. Arnold (Abstract No. 26)

2:50 P.M.—"Oxygen As A Factor in Electroluminescence Maintenance" by W. A. Thornton (Abstract No. 27)

3:15 P.M.—"Electroluminescence of ZnS Single Crystals" by D. R. Frankl (Abstract No. 28)

3:40 P.M.—"Image Forming Devices Using Sintered Photoconductors" by K. H. Butler (Abstract No. 29)

4:05 P.M.—"Particle Size Effects and the Distribution of Barriers in Electroluminescent Zinc Sulfide Phosphors" by Paul Goldberg (Abstract No. 30)

4:30 P.M.—"The Influence of Activator and Coactivator Concentrations on the Photoconductivity of Cadmium Sulfide Powders" by B. E. Bartels and M. S. Wasserman (Abstract No. 31)

5:00 P.M.—Electronics Division Business Meeting in the Washington Room (Mezzanine)

Electronics—Luminescence (cont'd)

Wednesday, April 30, 1958
with H. F. Ivey presiding
(WASHINGTON ROOM)

9:00 A.M.—"Luminescent Properties of ZnS Phosphors with Ga and In Coactivators" by E. F. Apple (Abstract No. 32)

9:30 A.M.—"ZnS:Cu Phosphor Produced by Radioactive Decay of Neutron-Irradiated ZnS" by J. Kastner, R. M. Potter, and M. Aven (Abstract No. 33)

10:05 A.M.—"Self-Activated Luminescent Center in ZnS Phosphors" by J. S. Prener and D. J. Weil (Abstract No. 34)

10:30 A.M.—"Energy Levels of Activators in Zinc Sulfide Phosphors" by C. F. Wahlig (Abstract No. 35)

10:55 A.M.—"Optical Anisotropy and Birefringence Banding in ZnS Crystals" by L. W. Strock, V. A. Brophy, and T. E. Peters (Abstract No. 36)

11:30 A.M.—"The Lead Oxide-Lead Sulfate and Lead Oxide-Lead Selenate Systems" by R. O. Jones and S. Rothschild (Abstract No. 37)

Electronics—Luminescence (cont'd)

Wednesday, April 30, 1958
with Luke Thorington presiding
(WASHINGTON ROOM)

2:00 P.M.—"Infrared Stimulation and Quenching of Photoconduction in Single-Crystal ZnS:Cu" by F. G. Ullman and J. J. Dropkin (Abstract No. 38)

2:25 P.M.—"Sintered CdS Photoconductors" by M. J. B. Thomas (Abstract No. 39)

3:00-4:30 P.M.—Round-table discussion

ELECTRONICS—
SEMICONDUCTORS

Monday, April 28, 1958
Semiconductor Materials Research
with N. B. Hannay presiding
(PENN TOP)

9:30 A.M.—Keynote Address—"Present Status of Semiconductor Materials Research" by D. K. Hartman (Abstract No. 40)

10:20 A.M.—"Solid Solubilities and Electrical Properties of Aluminum and Gallium in Germanium" by F. A. Trumbore and E. M. Porbansky (Abstract No. 41)

10:35 A.M.—"Solid Solubility of Tin in Silicon" by F. A. Trumbore, C. R. Isenberg, and E. M. Porbansky (Abstract No. 42)

10:50 A.M.—"A Sensitive Method of Measuring Optical Scattering in Silicon" by G. H. Schwuttke, O. A. Weinreich, and P. H. Keck (Abstract No. 43)

11:15 A.M.—"On the Crystal Chemistry of Semiconductors" by E. Mooser and W. B. Pearson (Abstract No. 44)

11:30 A.M.—"The Electronic Structure of Compounds Formed between Group VB to VIIB Elements" by E. Mooser and W. B. Pearson (Abstract No. 45)

11:45 A.M.—Recent News Papers. Short Abstracts of these papers will be available at the meeting.

Electronics—Semiconductors (cont'd)

Monday, April 28, 1958

Semiconductor Materials Research (cont'd)

(Compound Semiconductors) with H. P. R. Frederikse presiding
(PENN TOP)

2:00 P.M.—Keynote Address—"Semiconducting Compounds—A Challenge in Applied and Basic Research" by A. C. Beer (Abstract No. 46)

2:50 P.M.—"Recent Studies of the Properties of PbS, PbSe, and PbTe" by W. W. Scanlon (Abstract No. 47)

3:10 P.M.—"Interdiffusion by the Vacancy Mechanism in Binary Ionic Semiconductors" by R. F. Brebrick (Abstract No. 48)

3:25 P.M.—"Production of 1/f Noise by Radiation in Lead Sulfide Cells" by R. L. Williams (Abstract No. 49)

3:50 P.M.—"Preparation of Crystals of Hexagonal SiC" by D. R. Hamilton (Abstract No. 50)

4:05 P.M.—"High Pressure, High Temperature Growth of Cadmium Sulfide Crystals" by W. E. Medcalf and R. H. Fahrig (Abstract No. 51)

4:20 P.M.—Recent News Papers. Short abstracts of these papers will be available at the meeting.

5:00 P.M.—Richards Memorial Lecture—"Electrolysis of Nonaqueous Solutions" by A. Brenner in the Penn Top (18th floor)

Electronics—Semiconductors (cont'd)

Tuesday, April 29, 1958
Transport Phenomena
with H. F. Mataré presiding
(PENN TOP)

9:00 A.M.—Keynote Address—"Carrier Transport Phenomena in Semiconductor Crystals" by E. M. Conwell (Abstract No. 52)

9:50 A.M.—"Electron Mobility in Indium Phosphide" by M. Glicksman and K. Weiser (Abstract No. 53)

10:05 A.M.—"Recombination of Carriers in InSb" by R. N. Zitter, A. J. Strauss, and A. E. Attard (Abstract No. 54)

10:20 A.M.—"Avalanche Breakdown and Collector-Voltage-Saturation of Diffused Intrinsic Power Transistors" by C. Huang (Abstract No. 55)

10:45 A.M.—"Effects of Radiation on Germanium and Silicon" by G. C. Messenger and J. P. Spratt (Abstract No. 56)

11:00 A.M.—"Two New Transistor Switching Types" by C. S. McCarthy, Jr. (Abstract No. 57)

11:15 A.M.—Recent News Papers. Short abstracts of these papers will be available at the meeting.

12:15 P.M.—The Electrochemical Society Luncheon and Business Meeting in the Penn Top North (18th floor)

Electronics—Semiconductors (cont'd)

Tuesday, April 29, 1958
Diffusion
with I. A. Lesk presiding
(PENN TOP)

2:00 P.M.—Keynote Address—"Factors Influencing Diffusion Processes" by F. M. Smits (Abstract No. 58)

2:50 P.M.—"Diffusion Concentration Profiles by Analog Computation" by Worden Waring (Abstract No. 59)

3:05 P.M.—"Diffusion Control in Silicon by Carrier Gas Composition" by C. J. Frosch and L. Derick (Abstract No. 60)

3:20 P.M.—"Diffusion of Radioactive Antimony in Silicon" by J. J. Rohan, J. K. Kennedy, and N. E. Pickering (Abstract No. 61)

3:45 P.M.—"Diffusion into Silicon from Glassy Layers" by J. E. Cline and R. G. Seed (Abstract No. 62)

4:00 P.M.—"Effects of Heat Treatment on Diffused Silicon Material" by A. L. MacDonald and W. J. Heinecke (Abstract No. 63)

4:15 P.M.—Recent News Papers. Short abstracts of these papers will be available at the meeting.

5:00 P.M.—Electronics Division Business Meeting in the Washington Room (Mezzanine)

Electronics—Semiconductors (cont'd)

Wednesday, April 30, 1958

Physics and Chemistry of Semiconductor Surfaces with J. W. Faust presiding

(PENN TOP)

9:00 A.M.—Keynote Address—"Semiconductor Surface Phenomena" by A. Many (Abstract No. 64)

9:50 A.M.—"Effects of Certain Chemical Treatments and Ambient Atmospheres on Surface Properties of Silicon" by T. M. Buck and F. S. McKim (Abstract No. 65)

10:05 A.M.—"Effect of Various Etches on Recombination Centers at Germanium Surfaces" by G. Wallis and Shyh Wang (Abstract No. 66)

10:20 A.M.—"Saturation Current in Germanium and Silicon Electrodes" by J. B. Flynn (Abstract No. 67)

10:45 A.M.—"Theory of Electron Transfer Reactions at Semiconductor Electrodes" by J. F. Dewald (Abstract No. 68)

11:00 A.M.—"Experiments on Electron Transfer Reactions at the ZnO Electrode" by J. F. Dewald (Abstract No. 69)

11:15 A.M.—"Chemical Etching of Silicon, I. The System HF, HNO_3, H_2O" by B. Schwartz and H. Robbins (Abstract No. 70)

11:30 A.M.—Recent News Papers. Short abstracts of these papers will be available at the meeting.

Electronics—Semiconductors (cont'd)

Wednesday, April 30, 1958

Process Technology
with H. Pollack presiding
(PENN TOP)

2:00 P.M.—Keynote Address—"Status of Semiconductor Process Technology" by F. Biondi (Abstract No. 71)

2:50 P.M.—"On the Jet Etching of Germanium and Silicon" by P. F. Schmidt and D. A. Keiper (Abstract No. 72)

3:05 P.M.—"Determination of Crystal Orientation by High Intensity Reflectograms" by G. H. Schwuttke (Abstract No. 73)

3:20 P.M.—"Some Properties of Electroless Nickel Contacts to Silicon" by E. Matovich, P. J. Heinle, and J. E. McNamara (Abstract No. 74)

3:45 P.M.—"The Use of Organo-Substituted Hydrolyzable Silanes on Silicon Devices" by B. Schwartz (Abstract No. 75)

4:00 P.M.—"Photolithographic Techniques as Applied to Semiconductor Devices" by J. R. Nall and J. W. Lathrop (Abstract No. 76)

4:15 P.M.—Recent News Papers. Short abstracts of these papers will be available at the meeting.

Electronics—Semiconductors and Electrothermics and Metallurgy Joint Symposium

Thursday, May 1, 1958

Preparation, Evaluation, and Uses of High Purity Metals
Zone Refining Methods
with Morris Steinberg presiding
(PENN TOP)

9:00 A.M.-12:00 M.—*See* Electrothermics and Metallurgy Program for Thursday, May 1.

Preparation, Evaluation, and Uses of High Purity Metals (cont'd)

Iodide Processes
with John M. Blocher, Jr., presiding
(PENN TOP)

2:00 P.M.-5:30 P.M.—*See* Electrothermics and Metallurgy Program for Thursday, May 1.

ELECTROTHERMICS AND METALLURGY

Monday, April 28, 1958

Preparation, Evaluation, and Uses of High Purity Metals
Criteria of Purity
with Donald Wilkins presiding
(SKYTOP)

9:30 A.M.—Review Paper—"Review of Various Analytical Methods for Determination of Trace Impurities" by L. Pepkowitz (Abstract No. 77)

10:00 A.M.—"Spectrochemical Methods for Analyzing High Purity Hafnium" by T. A. Sullivan, R. W. Lewis, and J. L. Potter (Abstract No. 78)

10:30 A.M.—"X-Ray Fluorescent Analysis of Tin in Titanium in the Range of 0.03-0.50% Tin" by T. A. Sullivan, R. W. Lewis, and L. Carpenter (Abstract No. 79)

11:00 A.M.—"Determination of Hydrogen in Titanium and Its Alloys —A Critical Review" by T. D. McKinley (Abstract No. 80)

11:30 A.M.—"Some Applications and Methods for Low Level Analysis of Specific Impurities in Metals" by R. A. Wallace, Thomas Polanyi, and John Roboz (Abstract No. 81)

Electrothermics and Metallurgy—Corrosion

Monday, April 28, 1958

Stress Corrosion Cracking of Stainless Steels
with William Tragert presiding
(SKYTOP)

1:30 P.M.—"Stress Corrosion Cracking of Austenitic Stainless Steel" by J. J. Harwood (Abstract No. 82)

2:00 P.M.—"Mechanism of Stress Corrosion of Type 304 Stainless Steel" by H. L. Logan (Abstract No. 83)

2:30 P.M.—"Stress Corrosion Cracking of Some Homogeneous Alloys Containing Nickel" by H. R. Copson (Abstract No. 84)

3:00 P.M.—"Stress Corrosion of Austenitic Stainless Steel in High Temperature Water" by M. G. Fontana (Abstract No. 85)

3:30 P.M.—"Caustic Stress Corrosion of Type 347 Stainless Steel" by G. C. Wheeler and E. Howells (Abstract No. 86)

4:00 P.M.—"Cracking of Martensitic Stainless Steel under Conditions of Stress and Corrosion" by B. F. Brown (Abstract No. 87)

5:00 P.M.—Richards Memorial Lecture—"Electrolysis of Nonaqueous Solutions" by A. Brenner in the Penn Top (18th Floor)

Electrothermics and Metallurgy (cont'd)

Tuesday, April 29, 1958

Preparation, Evaluation, and Uses of High Purity Metals (cont'd)
Electrorefining and Electrowinning with H. H. Kellogg presiding

(SKYTOP)

9:00 A.M.—Paper voided. (Abstract No. 88)

9:30 A.M.—Review Paper—"Fused Salt Electrowinning and Electrorefining Methods" by M. E. Sibert (Abstract No. 89)

10:00 A.M.—"Fused Salt Electrorefining of Hafnium Metal" by D. H. Baker, Jr., J. R. Nettle, and J. Heigel (Abstract No. 90)

10:30 A.M.—"Elemental High Purity Boron Preparation with Emphasis on Fused Salt Electrolytic Methods" by E. W. Fajans, *et al.* (Abstract No. 91)

11:00 A.M.—"Fused Salt Electrorefining of Columbium Metal" by E. C. Hirakis and M. E. Sibert (Abstract No. 92)

11:30 A.M.—Paper voided. (Abstract No. 93)

12:15 P.M.—The Electrochemical Society Luncheon and Business Meeting in the Penn Top North (18th floor)

Electrothermics and Metallurgy (cont'd)

Tuesday, April 29, 1958

Preparation, Evaluation, and Uses of High Purity Metals (cont'd)
Chemical Purification Methods with Morris Kolodney presiding

(SKYTOP)

2:00 P.M.—Review Paper—"The Hy-

drogen Reduction Method for the Preparation of High Purity Tungsten and Rhenium" by C. Toensing (Abstract No. 94)

2:30 P.M.—"Aqueous Methods for the Preparation of High Purity Metals" by G. B. Wood (Abstract No. 95)

3:00 P.M.—"Preparation of Pure Chromium by a Vacuum Distillation Technique" by W. H. Smith and R. L. Hadley (Abstract No. 96)

3:30 P.M.—"Metallurgy of Uranium Refining" by B. Blumenthal (Abstract No. 97)

4:00 P.M.—"Phase Equilibrium Study of the System Na_2WO_4-Na_2CO_3-H_2O" by R. L. Pilloton and G. E. Crawley, Jr. (Abstract No. 98)

4:30 P.M.—"Methods for Preparing Pure Scandium Oxide" by F. H. Spedding, J. E. Powell, A. H. Daane, M. A. Hiller, and W. H. Adams (Abstract No. 99)

Electrothermics and Metallurgy (cont'd)

Wednesday, April 30, 1958

High Temperature Property Measurements
General Methods
with G. M. Butler presiding
(SKYTOP)

9:00 A.M.—"On the Measurement of the Temperatures of Unenclosed Objects by Radiation Methods" by A. Emslie and H. Blau (Abstract No. 100)

9:30 A.M.—"Thermal Conductivity Measurement in the Temperature Range 1000°-3000°F" by T. E. Waterman and I. B. Fieldhouse (Abstract No. 101)

10:00 A.M.—"Micro Furnace for Thermal Microscopy and Studies at High Temperatures" by W. A. Lambertson and G. Lewis (Abstract No. 102)

10:30 A.M.—"Water-Stabilized Arc Tests on Nonmetallic Materials" by M. Dank, R. A. Nelson, W. R. Sheridan, and W. H. Sutton (Abstract No. 103)

12:30 P.M.—Electrothermics and Metallurgy Luncheon and Business Meeting in the Buffalo Room (Mezzanine)

Electrothermics and Metallurgy (cont'd)

Wednesday, April 30, 1958

High Temperature Property Measurements (cont'd)
Metallic Materials
with Robert Carlson presiding
(SKYTOP)

2:00 P.M.—"Rigidity Relaxation in Recrystallized Tungsten Wires at Elevated Temperatures" by I. Berlec (Abstract No. 104)

2:30 P.M.—"Strength of Titanium at 1300°-1600°C" by E. Scala (Abstract No. 105)

3:00 P.M.—"The Activities of Refractory Metal Alloy Systems" by Rudolph Speiser and George St. Pierre (Abstract No. 106)

3:30 P.M.—"Vapor Pressure of Columbium" by Rudolph Speiser, Paul Blackburn, and Herrick Johnston (Abstract No. 107)

Electrothermics and Metallurgy and Electronics-Semiconductors Joint Symposium

Thursday, May 1, 1958

Preparation, Evaluation, and Uses of High Purity Metals (cont'd)
Zone Refining Methods
with Morris Steinberg presiding
(PENN TOP)

9:00 A.M.—Review Paper—"Contributions of Zone Melting to High Purity Materials" by F. H. Horn (Abstract No. 108)

10:00 A.M.—"Application of the Floating Zone Technique to Metals" by R. L. Smith, J. L. Rutherford, and M. Herman (Abstract No. 109)

10:30 A.M.—"Tungsten Zone Melting by Electron Bombardment" by R. G. Carlson (Abstract No. 110)

11:00 A.M.—"Techniques and Results of Zone Refining Some Metals and Semiconducting Compounds" by J. H. Wernick, K. E. Benson, D. Dorsi, and J. J. Gillich (Abstract No. 111)

11:30 A.M.—"Continuous Multistage Zone Melting of Silicon Tetraiodide" by G. H. Moates and B. Rubin (Abstract No. 112)

Electrothermics and Metallurgy and Electronics-Semiconductors Joint Symposium

Thursday, May 1, 1958

Preparation, Evaluation, and Uses of High Purity Metals (cont'd)
Iodide Processes
with John M. Blocher, Jr., presiding

(PENN TOP)

2:00 P.M.—"Principles and Application of the Iodide Process" by A. C. Loonam (Abstract No. 113)

2:25 P.M.—"The Iodide Process for High Purity Silicon Preparation" by F. B. Litton (Abstract No. 114)

2:50 P.M.—"Some Aspects of the Decomposition of Silicon Tetraiodide" by A. F. Armington and B. Rubin (Abstract No. 115)

3:15 P.M.—"Zirconium Coating of Uranium by the Iodide Process" by W. L. Robb (Abstract No. 116)

3:40 P.M.—"High Purity Silicon from Silicon Tetraiodide Purified by Solvent Recrystallization and Distillation" by L. V. McCarty (Abstract No. 117)

4:05 P.M.—"Plating of Tungsten with Titanium and Zirconium by the Van Arkel-de Boer Process" by H. T. Stephenson (Abstract No. 118)

4:30 P.M.—"High Purity Crystalline Boron" by D. R. Stern and Lahmer Lynds (Abstract No. 119)

INDUSTRIAL

ELECTROLYTIC

Monday, April 28, 1958

Fused Salt Electrolysis
with M. Janes presiding

(WASHINGTON ROOM)

10:00 A.M.—"Electrodeposition of Adherent Titanium Coatings on Induction Heated Cathodes in Fused Salts" by J. G. Wurm, B. J. Fortin, L. Gravel, and R. J. A. Potvin (Abstract No. 120)

10:30 A.M.—"Refining of Titanium Scrap by Fluoride Electrolysis" by S. S. Carlton and B. C. Raynes (Abstract No. 121)

12:15 P.M.—Industrial Electrolytic Division Luncheon and Business Meeting in the Penn Top North 18th floor)

Industrial Electrolytic (cont'd)

Monday, April 28, 1958

General Industrial Electrolytic
with J. C. Cole presiding
(WASHINGTON ROOM)

2:00 P.M.—"Report of the Chlor-Alkali Committee" by J. C. Cole and R. B. MacMullin (Abstract No. 122)

2:30 P.M.—"Effect of Gas Evolution on Current Distribution and Cell Resistance" by C. W. Tobias (Abstract No. 123)

3:00 P.M.—"Investigations on the Structure of the Color Compound in Caustic" by S. Wawzonek and D. S. P. Eftax (Abstract No. 124)

5:00 P.M.—Richards Memorial Lecture—"Electrolysis of Nonaqueous Fluids" by A. Brenner in the Penn Top (18th floor)

THEORETICAL ELECTROCHEMISTRY

Monday, April 28, 1958

Electrokinetic and Membrane Phenomena
with Paul Delahay presiding
(GOLD BALLROOM)

9:30 A.M.—"Relative Rates of Electromigration of Different Ions of the Same Charge across Permselective Membranes" by Rex Neihof, Ruth McClintock, and Karl Sollner (Abstract No. 125)

10:00 A.M.—"Improved Protamine Collodion Membranes of Extreme Ionic Selectivity" by Marc Lewis and Karl Sollner (Abstract No. 126)

10:50 A.M.—"Transport Processes in Ionic Membranes" by K. S. Spiegler (Abstract No. 127)

11:20 A.M.—"Transport in Ion-Selective Membranes" by M. A. Peterson and H. P. Gregor (Abstract No. 128)

Theoretical Electrochemistry (cont'd)

Monday, April 28, 1958

Electrokinetic and Membrane Phenomena (cont'd)
with R. Hurd presiding
(GOLD BALLROOM)

2:00 P.M.—"Transport against the Chemical or Electrochemical Gra-

dient in Charged Porous Membranes" by Richard Schlögl
(Abstract No. 129)

2:50 P.M.—"Membrane Potentials in Isothermal and Nonisothermal Systems; A Detailed Investigation of a Single Membrane System" by G. J. Hills and P. W. M. Jacobs
(Abstract No. 130)

3:40 P. M.—"Electro-Osmosis and Electro-Convection in Ionic Membranes; Relation between Electro-Osmotic Transport, Ionic Conduction, Ionic Self-Diffusion, and the Degree of Counter-Ion Solvation" by G. J. Hills and P. W. M. Jacobs
(Abstract No. 131)

4:20 P. M.—"Phenomenological Electrochemistry of Membranes" by George Scatchard
(Abstract No. 132)

5:00 P.M.—Richards Memorial Lecture—"Electrolysis of Nonaqueous Solutions" by A. Brenner in the Penn Top (18th floor)

Theoretical Electrochemistry (cont'd)

Tuesday, April 29, 1958

Electrokinetic and Membrane Phenomena (cont'd) with Ralph Roberts presiding

(GOLD BALLROOM)

9:00 A.M.—"Streaming Potentials of Corundum in Organic Electrolyte Solutions" by H. J. Modi and D. W. Fuerstenau (Abstract No. 133)

9:30 A.M.—"Interpretations of Experimental Donnan Equilibria Obtained with Polyphosphates" by U. P. Strauss (Abstract No. 134)

10:00 A.M.—"Direct Determination of Adsorption of Organic Molecules at Solid Electrodes" by B. E. Conway and R. G. Barradas
(Abstract No. 135)

10:40 A.M.—"Electrokinetic Measurements on Stainless Steel Capillaries" by B. Levy and A. R. Fritsch (Abstract No. 136)

11:10 A.M.—"Surface Conductance of Clays" by H. van Olphen
(Abstract No. 137)

12:15 P.M.—The Electrochemical Society Luncheon and Business Meeting in the Penn Top North (18th floor)

Theoretical Electrochemistry (cont'd)

Tuesday, April 29, 1958

Electrokinetic and Membrane Phenomena (cont'd)
with Ralph Roberts presiding

(GOLD BALLROOM)

2:00 P.M.—"Membrane Phenomena in Applied Geophysics" by M. Gondouin (Abstract No. 138)

2:30 P.M.—"Influence of Firing Conditions, Composition, and Screening Media on the Zeta Potentials of ZnS Phosphors as Related to Adherence to Glass Surfaces" by B. Levy (Abstract No. 139)

3:00 P.M.—"The Electrokinetic Potential and Some Surface Tension Phenomena" by L. B. Robinson (Abstract No. 140)

General Session
with Paul Delahay presiding

3:45 P.M.—"Overvoltage and Catalysis" by Paul Ruetschi (Abstract No. 141)

4:15 P.M.—"Cathodic and Anodic Properties of Chlorine on Carbon and Graphite Surfaces" by John Aylward, Ernest Yeager, and Frank Hovorka (Abstract No. 142)

Theoretical Electrochemistry (cont'd)

Wednesday, April 30, 1958

General Session (cont'd)
with A. J. de Bethune presiding

WEST ROOM

9:00 A.M.—"Electrode Potentials of Titanium-Oxygen Alloys" by R. S. Dean, I. Hornstein, and W. W. Gullett (Abstract No. 143)

9:30 A.M.—"Mechanisms of Hydrogen Producing Reactions on Palladium, V. The Deuterium-Palladium System" by Sigmund Schuldiner and J. P. Hoare (Abstract No. 144)

10:00 A.M.—"Double Layer Structure and Electrode Processes, I. Salt Effect" by Manfred Breiter, Marcos Kleinerman, and Paul Delahay (Abstract No. 145)

10:40 A.M.—"Double Layer Structure and Electrode Processes, II. Discharge of Certain Metallic Complexes" by Paul Delahay and Carl Weis (Abstract No. 146)

11:20 A.M.—Theoretical Electrochemistry Division Business Meeting in the Penn Top North (18th floor)

Theoretical Electrochemistry (cont'd)

Wednesday, April 30, 1958

General Session (cont'd)
with C. W. Tobias presiding
WEST ROOM

2:00 P.M.—"Schlieren Studies of Concentration Gradients at a Cu|HCl Anode" by R. S. Cooper (Abstract No. 147)

2:30 P.M.—"The Nature of the Current Flow at or between Cylindrical Electrodes" by R. D. Barnard and S. M. Skinner (Abstract No. 148)

3:00 P. M.—"Electromotive Force Measurements in Cerium-Cerium Chloride Liquid Systems" by S. Senderoff and G. W. Mellors (Abstract No. 149)

3:50 P.M.—"Activities of $NiCl_2$ from EMF Measurements in Molten LiCl-KCl" by R. D. Walker, Jr., and D. E. Danly (Abstract No. 150)

4:20 P.M.—"Electropolishing Silicon in Hydrofluoric Acid Solutions" by D. R. Turner (Abstract No. 151)

Theoretical Electrochemistry (cont'd)

Thursday, May 1, 1958

General Session (cont'd)
with S. Schuldiner presiding
(SKY TOP)

9:00 A.M.—"Thermodynamics of Electron Atmospheres at Interfaces" by S. M. Skinner (Abstract No. 152)

9:30 A.M.—"Codeposition of Nickel and Hydrogen from Simple Aqueous Solutions" by John Yeager, J. P. Cels, Ernest Yeager, and Frank Hovorka (Abstract No. 153)

10:00 A.M.—"Effect of Addition Agents on Tungsten Codeposition" by J. S. Sallo and R. D. Fisher (Abstract No. 154)

10:00 A. M.—"Anodic Oxidation of Zinc and a Method of Altering the Characteristics of the Anodic Films" by H. Fry and Marjorie Whitaker (Abstract No. 155)

11:20 A.M.—"Anodic Dissolution of Magnesium in Aqueous Solution" by Richard Glicksman
(Abstract No. 156)

ABSTRACTS

In the Index to Authors the Abstract Number is the number listed in the right-hand column.

ELECTRIC INSULATION

Abstract No. 1

Effect of Temperature and Thickness on the Electrical Resistivity of Ceramic Coatings

W. H. Fischer, General Engrg. Lab., General Electric Co., 1 River Rd., Schenectady 5, N. Y.

Tests show that the electrical resistivity of ceramic coatings less than 3 mils thick varies with thickness, although the variation of resistivity with temperature is normal. It is believed that the resistivity-thickness variation is due to surface irregularities and metal-ceramic interface factors which together produce nonuniform, nonhomogenous coatings. Consequently, electrical characteristics of ceramic coatings intended for electrical insulation use should be evaluated only from measurements made on coatings closely approximating actual service thicknesses.

Abstract No. 2

High Temperature Aluminum Oxide Insulation for Wire and Strips

Henry Walker, Permaluster, Inc., Burbank, Calif.

The Permaluster Process (electrochemical anodic oxidation) creates a very thin film which has the properties to protect against corrosion, is highly insulating, and provides great heat resistance up to approximately 3650°F. The film is flexible and can be furnished in colors. It is aluminum oxide, created from the aluminum to which it is applied. It can be provided on other metals such as Cu, Ag, and Pt, provided they are Al clad.

Abstract No. 3

Progress in High Frequency Ceramic Dielectric Insulation

E. J. Smoke, School of Ceramics, Rutgers, The State University, New Brunswick, N. J., and **S. DiVita,** U. S. Army Signal Engineering Lab., Fort Monmouth, N. J.

U. S. Army Signal Corps sponsored research on high frequency ceramic dielectric insulation at Rutgers, The State University, has resulted in many interesting findings. The project is divided into several problems, namely, ultra low loss, thermal shock resistance, impact resistance, thermal conductivity, nonshrinking ceramics, etc. These are discussed in terms of the problem, the basic principles involved, and progress to date.

Abstract No. 4

Ultra Low Loss, High Frequency Dielectric Insulators

E. J. Smoke, School of Ceramics, Rutgers, The State University, New Brunswick, N. J., and **S. DiVita,** U. S. Army Signal Engineering Lab., Fort Monmouth, N. J.

The best ultra low loss electrical properties at high frequencies are attained with pure oxide single crystals and pure single oxide glasses and polycrystalline ceramics. However, these have limited use because of fabricating difficulties, particularly in making larger specimens. When the size factor is important and refractoriness is not, polycrystalline fluxed bodies, maturing at relatively low temperatures, become important. Wollastonite and quartz-type bodies fluxed with lead and alkaline earth compounds are discussed, including physical and electrical properties, and compared to single crystals.

Abstract No. 5

Boron Nitride, a Machinable High Temperature Insulation Material

J. J. McGahan, Carborundum Co., Niagara Falls, N. Y.

(No abstract received)

Abstract No. 6

The Effect of the Crystalline and Glassy Phases on the Dielectric Properties of Ceramic High Frequency Insulation

B. R. Eichbaum, Research Lab., International Business Machines Corp., Poughkeepsie, N. Y.

The method of tailor making ceramic insulation for specific purposes has not been used because the effect of both the glass and crystalline phases on the fired body composition was not known. This investigation of the effect of the glass and crystalline phases of ceramic insulation (operating at megacycle) should aid in developing bodies with specific requirements.

In this study the dielectric constant and power factor of the crystal phases of wollastonite, quartz, and alumina and of a bonding glass were determined and calculations (using Niesel's, Lichtenecker's and Maxwell's Law of Mixtures) were used to determine the properties of such ceramic bodies. Special techinques were used to determine the properties of these materials and to determine the volume per cent of each phase present in the fired bodies in order to check the theory with practical results.

The findings of this investigation were used to develop a very low loss quartz-type ceramic body.

Abstract No. 7

Some Current Problems in the Production of Magnetic Ceramics

George Economos, Lab. for Insulation Research, Massachusetts Institute of Technology, Cambridge, Mass.

Reproducibility of the electrical and magnetic properties is still the main difficulty in quantity production of magnetic ceramics. In addition, the mechanical tolerances of the user must be met. These two major problems are discussed from a developmental viewpoint with suggestions for improving present methods. Current efforts at standardizing acceptable testing specifications for the various applications are outlined also.

Abstract No. 8

D. T. A. Characteristics of Barium Titanate

K. G. Skinner, U. S. Naval Research Lab., Washington, D. C.

Differential thermal analyses (d. t. a.) were made of barium titanate samples and of sized-fractions obtained from them. The samples included both commercially available and laboratory-prepared materials. The d. t. a. characteristics showed not only the differences between as-received samples but also between sized-fractions of the same sample. These differences included *(a)* completeness of chemical reactions between components, *(b)* presence of undesired compounds, from a purity or a piezo-electric standpoint, such as Ba_2TiO_4, $BaTi_2O_5$, and $BaTi_3O_7$, *(c)* phase change temperatures, such as the tetragonal-cubic transition of $BaTiO_3$, and *(d)* approximate temperature at which coalescence (shrinkage) begins. The observed differences in chemical character have been related to ceramic fabrication behavior and to electrical properties of finished bodies.

Abstract No. 9

Flammability Testing of Plastics

L. V. Larsen, Laminated Products Div., General Electric Co., Coshocton, Ohio

This paper discusses a severe test for flammability in which the specimen is exposed to a high temperature source of heat with a spark present to ignite gaseous products of combustion. The results obtained in this test are in terms of the ignition time and the burning time.

A number of the factors influencing the precision and reproducibility of the test procedure are discussed. These include mass of specimen, temperature of source of heat, and rate of ventilation.

Abstract No. 10

Damage to Plastic Insulation Caused by Heavy Forming Die Pressures

F. H. Wells and J. H. Whitley, AMP Incorporated, Harrisburg, Pa.

Plastic insulation used on crimp-type electric wire terminations must

maintain high dielectric strength after severe mechanical abuse suffered in the crimping operation. Elementary mechanical properties of the plastics often fail to predict their performance in this application. A notable example is reported here, where peculiar stress-relaxation effects were observed in polyvinyl chloride-acetate. The dielectric strength of tubular specimens remained high while under heavy die pressure, but fell sharply after pressure was removed.

Abstract No. 11

Flashover Strength of Plastics

L. J. Frisco and **J. J. Chapman,** Dielectrics Lab., The Johns Hopkins University, Baltimore, Md.

Surface flashover strength has been measured at impulse and d-c voltage and at alternating voltages over the frequency range from 60 cps to 100 mc. Data on the effects of frequency, ambient temperature, moisture absorption, material properties, and electrode configuration demonstrate the influence of these factors on surface failure.

Abstract No. 12

Results of Reinforced and Laminated Plastics Survey

L. R. Samelson, Lake Publishing Co., Lake Forest, Ill.

More than 2200 individuals have cooperated in a mail questionnaire survey on reinforced and laminated plastics used in the electrical and electronic industries. Topics covered include: forms used, applications, improvements desired, information required, standards and specifications, volume used, grades used, etc. Survey results serve as a guide to common problems needing solution in connection with these plastics.

Abstract No. 13

LEXAN Polycarbonate Resin

G. C. Calderwood, Chemical Development Dept., General Electric Co., Pittsfield, Mass.

LEXAN molding compound is a polycarbonate resin developed by the General Electric Co. Its unusual chemical composition offers a com-

bination of toughness and heat stability not previously available in thermoplastic materials. LEXAN resin is a completely new thermoplastic molding compound which is characterized by the following unique properties: *(a)* high impact strength; *(b)* excellent dimensional stability; (c) superior heat resistance; (*d*) good electrical properties.

Abstract No. 14

Processing Effects on High Pressure Thermosetting Laminates Used in the Manufacture of Printed Wiring Boards

St. John Bain, Formica Corp., Cincinnati, Ohio

This paper discusses: *(a)* electrical and physical properties of various laminates pertinent to printed wiring board; *(b)* effects of various processing chemicals on copper-clad laminates, including chemical and dimensional changes experienced as a result of degreasing, baking, etching, electroplating, fluxing, and soldering; and *(c)* effects of environmental aging on printed wiring boards, presenting data on the variation in electrical properties as a function of several accelerated aging conditions.

Abstract No. 15

Environmental Conditioning

Elmer Varga, Hughes Systems Development Labs., Culver City, Calif.

A major requirement for military equipment is that it will operate properly under extremes of environmental conditions.

This paper discusses the use of environmental conditioning for the purpose of building into etched circuit assemblies the necessary resistance to environment.

This conditioning finds important use in *(a)* qualification of raw material; *(b)* acceptance tests of incoming raw materials; *(c)* evaluation of the effect of individual processes on the quality of the finished board; *(d)* control of the manufacturing operations; *(e)* inspection tests of finished etched circuit boards.

The application of environmental tests to determine manufacturing capabilities, solder joint reliability, surface contamination, and effectiveness of protective coatings is presented.

Abstract No. 16

Organic Coatings in Printed Wiring

B. G. Brand, Battelle Memorial Institute, Columbus 1, Ohio

The paper presents a brief review of the main methods of production of printed circuits and the role of organic coatings in this production. Requirements of coating materials for the different applications as well as places where improvements are desired are discussed. Attention must be given to mechanical, chemical, electrical properties in the choice of proper materials.

Abstract No. 17

Etching Control

D. Alnutt, Philip A. Hunt Co., Palisades Park, N. J.

A discussion is given on the chemistry of etching, especially when using iron chloride and nitric acid solutions. The effects of temperature, Baume free acid content, etc., on the quality and speed of etching are discussed also. In addition, a new powderless method of etching copper as used for halftone work is explained. The method may have application for printed wiring work.

Abstract No. 18

Plating Considerations for Printed Wiring

W. H. Hannahs, Automatic Production Research, Mount Vernon, N. Y.

The effects of plating solutions, especially cyanide baths, on laminated base materials are discussed as well as special consideration of plating baths used for printed wiring work and control of plating baths, considering that organic substances are immersed in the bath.

Abstract No. 19

Improved High Temperature Resistance of Copper Clad Teflon-Fiberglas Laminate

A. H. Haroldson, Continental-Diamond Fibre Div., Budd Co., Inc., Newark, Del.

At elevated temperatures the surface of the copper foil next to the substrate oxidizes and causes a loosening of the bond. A number of methods have been studied to prevent deterioration of the copper surface. The best results have been attained with a nickel plated copper foil. When the copper surface has been treated to prevent oxidation the laminate can be subjected to 500°F continuously, without any loss of bond strength.

ELECTRONICS—LUMINESCENCE

Abstract No. 20

Use of Polarized Light in the Study of Luminescent Systems

C. C. Klick, U. S. Naval Research Lab., Washington, D. C.

(No abstract received)

Abstract No. 21

Effect of Impurities on the Plaque Brightness of a 3000°K Calcium Halophosphate Phosphor

A. Wachtel, Research Dept., Westinghouse Electric Corp., Bloomfield, N. J.

The killing action of 27 elements on a specially purified 3000°K calcium halophosphate phosphor has been investigated. At 1% addition, the observed reduction in output increases in the order: Al, Zr, Ce, La, Pb, Y, In, Sm, Cs, S, Pr, Nd, Na, Ag, Sn, W, Si, Mo, U, Ga, Cr, Ni, Fe, Cu, Co, V, and Ti. In the neighborhood of 100 ppm, the first five elements listed showed a slight enhancing effect. None of the elements tested had an appreciable effect on the color of fluorescence, except where killing of the luminescence became very pronounced. The use of capped silica tubes enabled firings with a reproducibility of ±0.3%.

Abstract No. 22

The System $ZnO.CdO.B_2O_3$, Phase Relationships and Fluorescence

D. E. Harrison, Luminescent Materials Lab., Lamp Wire and Phosphors Dept., General Electric Co., Cleveland, Ohio, and **F. A. Hummel,** Dept. of Ceramic Technology, Pennsylvania State University, University Park, Pa.

The subsolidus phase relationships were investigated using x-ray and petrographic methods. Two compounds were isolated: $2ZnO.CdO.B_2O_3$ which fuses at ca. 860°C and $ZnO.2CdO.2B_2O_3$ which melts congruently at 797° ±3°C. Excitation by either 2537Å or cathode rays produces an orange fluorescence in $2ZnO.CdO.B_2O_3$ with 0.004 wt% Mn and a red fluorescence in $ZnO.2CdO.2B_2O_3$ with 0.082 wt% Mn. The fluorescence of $ZnO.2CdO.2B_2O_3$ was examined using Ag, Sn, Tl, Pb, and Sb as single activators, as well as sensitizers in conjunction with Mn.

Abstract No. 23

Phase Equilibria in the System $ZnO-P_2O_5$

F. L. Katnack and **F. A. Hummel,** Dept. of Ceramic Technology, Pennsylvania State University, University Park, Pa.

Phase relationships in the system $ZnO-P_2O_5$ were determined in the range between ZnO and $Zn(PO_3)_2$. Three congruently melting compounds exist, $Zn_3(PO_4)_2$, $Zn_2P_2O_7$, and $Zn(PO_3)_2$. The orthophosphate has a sluggish, reversible inversion at 942° and melts at 1060° ±8°. The pyrophosphate undergoes a rapid, reversible inversion at 132° and melts at 1017°. An irreversible inversion in the metaphosphate takes place in air in the range between 600° and 700°. Simple eutectic relationships exist between ZnO and $Zn_3(PO_4)_2$, $Zn_3(PO_4)_2$ and $Zn_2P_2O_7$, and $Zn_2P_2O_7$ and $Zn(PO_3)_2$.

Abstract No. 24

Phosphors in the System Magnesia-Cadmium Oxide-Zinc Oxide-Silica

P. G. Herold, Electron Tube Div., Radio Corp of America, Lancaster, Pa.

This paper describes four new compounds which are tentatively identified as: *(a)* $5MgO.2CdO.ZnO.7SiO_2$, *(b)* $2CdO.ZnO.SiO_2$, *(c)* $2MgO.4CdO.3SiO_2$, and *(d)* $MgO.2CdO.SiO_2$. The first of these compounds shows good cathodoluminescent properties. When it is activated with 4 mole % Mn and fluxed with $CdCl_2$, it has a peak wave length of 6380Å, a peak efficiency equal to 85% that of Mn-activated Zn orthophosphate, and very little saturation at high current densities.

Abstract No. 25

Some Observations on Aluminum Nitride

C. Buhrer and **E. Banks,** Polytechnic Institute of Brooklyn, Brooklyn, N. Y.

Aluminum nitride has been prepared by several methods. The purest material is obtained by the thermal decomposition of an aluminum chloride-ammonia complex. This material is nonluminescent, while a less pure material prepared from the metal has a blue luminescence. Conductivity data on a sample of the impure material and the diffuse reflectance spectrum of the pure material are presented. It is suggested tentatively that the blue fluorescence is associated with a stoichiometric excess of aluminum.

Abstract No. 26

Applications of Luminescence in Glass

R. J. Ginther, J. H. Schulman, and **G. W. Arnold,** U. S. Naval Research Lab., Washington, D. C.

Luminescent glasses are currently being explored for possible application as scintillators, cathode ray screens, or light sources. For scintillation counting purposes Ce-activated glasses appear to be most promising. Cathode ray screens composed of Mn-, Cu-, and Ce-activated vycor have been prepared. The screen brightness of the Mn-activated glass is about one-third that of a ZnS(Mn) film. Cerium- and Sm-activated vycor are high temperature phosphors and may find application as light sources.

Abstract No. 27

Oxygen As A Factor in Electroluminescence Maintenance

W. A. Thornton, Research Dept., Westinghouse Electric Corp., Bloomfield, N. J.

The assumption that oxygen enters zinc sulfide phosphor crystals during electroluminescence, and thereby introduces electron traps which are considerably deeper than those found in good electroluminescent phosphors containing no added oxygen, is sufficient to explain the extensive experimental data; such traps are expected to have a quenching effect on the electroluminescence light output.

Abstract No. 28

Electroluminescence of ZnS Single Crystals

D. R. Frankl, Sylvania Electric Products Inc., Bayside, N. Y.

Studies of emission from certain ZnS:Cu crystals under pulsed voltage excitation suggest the following mechanisms: *(a)* excitation occurs by impact of electrons which enter the crystal by tunneling and are accelerated to several ev energy in the strong electric field in a barrier; *(b)* emission occurs by capture either of these electrons or of slow electrons that return to the barrier region on removal of the voltage. These mechanisms are shown to be capable of accounting qualitatively for the observed behavior under sinusoidal excitation.

Abstract No. 29

Image Forming Devices Using Sintered Photoconductors

K. H. Butler, Sylvania Electric Products, Inc., Salem, Mass.

Two image-forming devices using sintered photoconductive layers in conjunction with electroluminescent layers are described. One device employs feedback of light to allow indefinite holding of an image, while the second device eliminates all feedback to permit reproduction of a moving image. Equivalent circuits of the devices are used to explain their characteristics.

Abstract No. 30

Particle Size Effects and the Distribution of Barriers in Electroluminescent Zinc Sulfide Phosphors

Paul Goldberg, Central Research Labs., Sylvánia Electric Products Inc., Bayside, N. Y.

The particle size of electroluminescent phosphors is found to be a significant factor in empirical equations describing brightness-voltage relationships. These observations can be understood by considering *(a)* distribution of barriers in an electroluminescent particle, *(b)* division among the barriers of the voltage drop per particle, and *(c)* dependence on the particle size of the voltage drop per particle. Equations are derived which permit a meaningful comparison of the brightness of different phosphors.

Abstract No. 31

The Influence of Activator and Coactivator Concentrations on the Photoconductivity of Cadmium Sulfide Powders

B. E. Bartels and **M. S. Wasserman,** Sylvania Electric Products Inc., Flushing 54, N. Y.

Analyses of photoconductive CdS powders reveal an interdependence between the activator and coactivator concentrations retained after synthesis. In powders prepared with controlled amounts of activator (Cu) and excess coactivator (Cl), the amount of retained coactivator is found to be closely related to the activator content, and independent of the excess coactivator present during preparation. As the copper content is increased, the mole ratio Cu/Cl increases, passing unity in the range in which photoconductive sensitivity is a maximum. In the same range there are marked changes in spectral response and dark conductivity. Optical and electrical data are related to the analyses of the powders in such a way that tentative conclusions can be drawn.

Abstract No. 32

Luminescent Properties of ZnS Phosphors with Ga and In Coactivators

E. F. Apple, Research Lab., General Electric Co., Schenectady, N. Y.

In ZnS:(Cu,Ag,Au)(Ga,In) the luminescence observed depends on structure, activator concentration, and coativator identity. Cubic phosphors containing 10^{-4} g/atoms activator and coativator/mole ZnS show green, blue, and yellow-green emissions typical of Cu, Ag, Au, respectively. In hexagonal materials the emission is yellow with Ag, orange with Cu, and orange-red with Au. These effects, which are observed at room temperature with In and at lower temperatures with Ga, can be interpreted qualitatively by means of the Schön-Klasens theory of hole migration.

Abstract No. 33

ZnS:Cu Phosphor Produced by Radioactive Decay of Neutron-Irradiated ZnS

J. Kastner, R. M. Potter, and **M. Aven,** Lamp Development Dept., General Electric Co., Cleveland, Ohio

ZnS powder was irradiated in a high density thermal neutron flux to form radioactive Zn-65, Zn-69, and S-35. These radioisotopes decay to randomly distributed Cu-65, Ga-69, and Cl-35, respectively. Approximately one week after removal from the nuclear reactor the sample was fired at 900°C. The optical properties of the sample were determined during the ensuing ten-month decay period. Experimental findings are presented and interpreted in the light of current theories of luminescence in ZnS.

Abstract No. 34

Self-Activated Luminescent Center in ZnS Phosphors

J. S. Prener and **D. J. Weil,** Research Lab., General Electric Co., Schenectady, N. Y.

A model for the ground state of the self-activated luminescent center in ZnS phosphors proposed by Prener and Williams in 1956 has

been confirmed experimentally. It is shown that a Zn vacancy is involved in the blue luminescence and that the spectrum depends on whether the required coativator can occupy a Zn or S site near the vacancy. The calculated energy levels of the center using a simple model are in qualitative agreement with the observed spectra.

Abstract No. 35

Energy Levels of Activators in Zinc Sulfide Phosphors

C. F. Wahlig, Photo Products Dept., E. I. du Pont de Nemours & Co., Experimental Station, Wilmington, Del.

Measurements of the decrease of emission peak intensity under 3650Å u.v. excitation with increasing temperature tend to confirm the existence of two basic levels in self-activated ZnS identical with those proposed by Browne.* Changes in the position of the basic levels, 0.9 ev and 1.6 ev above the valence band, upon including Ag, Cu, or Mn activator in the phosphor formulation have also been investigated.

*P. F. Browne, *J. Electronics*, **2**, 154 (1956).

Abstract No. 36

Optical Anisotropy and Birefringence Banding in ZnS Crystals

L. W. Strock, V. A. Brophy, and **T. E. Peters,** Research Lab., Sylvania Electric Products Inc., Bayside, N. Y.

Electroluminescent ZnS crystals with 3-layer x-ray structure and banded birefringence exhibit strong anisotropy in light emission—fields applied perpendicular to the [c] direction producing brightest emission. Crystals with 2-layer structure also show similar banding. Experiments on the decay of the birefringence at elevated temperatures have shown that the decay time is at least two orders of magnitude slower for the 2-layer compared with the 3-layer structure crystals. These data, combined with parallel x-ray studies of structural changes accompanying the birefringence decay, provide a useful means of de-

termining the role of structural disorder in the host crystal of electroluminescent phosphors.

Abstract No. 37

The Lead Oxide-Lead Sulfate and Lead Oxide-Lead Selenate Systems

R. O. Jones and S. Rothschild, Mullard Research Labs., Cross Oak Lane, Salfords, Nr. Redhill, Surrey, England

The lead oxide-lead sulfate and lead oxide-lead selenate systems have been investigated using the room temperature x-ray powder method. The two systems are very similar and the preparation and x-ray powder patterns are given of lead sulfate $PbSO_4$, and lead monoxysulfate $PbO.PbSO_4$, lead tetroxysulfate $4PbO.PbSO_4$, lead selenate $PbSeO_4$, lead monoxyselenate $PbO.PbSeO_4$, and lead tetroxyselenate $4PbO.PbSeO_4$. The lead oxyselenates are isomorphous with the corresponding lead oxysulfates and the pattern of lead monoxyselenate has been indexed on the basis of a monoclinic unit cell of dimensions. $a=13.94°A$, $b=5.78°A$, $c=7.25°A$, $\beta=115.9°$.

Abstract No. 38

Infrared Stimulation and Quenching of Photoconduction in Single-Crystal ZnS:Cu

F. G. Ullman and J. J. Dropkin, Polytechnic Institute of Brooklyn, Brooklyn, N. Y.

The photoconduction of laboratory grown single crystals of Zns:Cu in the near infrared has been studied as a function of light intensity and electric field with and without simultaneous 3650Å radiation. Infrared alone produces photocurrents even in an unexcited crystal. This photocurrent quenches the u.v. photocurrent. The stimulation and quenching spectrum for infrared photocurrent has been determined and compared to published luminescence quenching spectra and excitation spectra for infrared emission and to previously postulated mechanisms.

Abstract No. 39

Sintered CdS Photoconductors

M. J. B. Thomas, Sylvania Electric Products Inc., Salem, Mass.

The effects of composition and firing procedure on the optical and electrical properties of thin photoconductive layers, formed by sintering cadmium sulfide powder, are described. Photocurrent, dark current, decay rate, and spectral sensitivity data are included. These characteristics are compared with those of films formed from unsintered powders.

ELECTRONICS— SEMICONDUCTORS

Abstract No. 40

Present Status of Semiconductor Materials Research

D. K. Hartman, General Electric Co., Syracuse, N. Y.

It was just a decade ago that transistor action was first announced by Bardeen and Brattain. No small part of the advances made in transistor technology during the ensuing period have been credited to materials research in processing and purification. Today, because of these advances, both germanium and silicon are finding wide acceptance in the semiconductor industry. There are still problems associated with these materials but it is the general consensus of many of the semiconductor manufacturers that present-day devices are not materials limited. It is the intent of this paper to review pertinent work in technological advancement that has made this materials position possible and to give some insight as to the present status of semiconductor materials research.

Abstract No. 41

Solid Solubilities and Electrical Properties of Aluminum and Gallium in Germanium

F. A. Trumbore and **E. M. Porbansky,** Bell Telephone Labs., Inc., Murray Hill, N. J.

The distribution coefficients of Al and Ga in Ge, determined from

crystal pulling experiments, fall from 0.08-0.09 at the melting point of Ge (937°C) to 0.04-0.05 at 900°C. The most heavily doped crystals, with acceptor concentrations of 2×10^{20} atoms/cc, had room temperature resistivities of 0.0003 ohm-cm corresponding to hole mobilities of about 70 cm^2/v-sec. Solid solubilities and resistivities were also obtained on crystals grown at lower temperatures by thermal gradient crystallization.

Abstract No. 42

Solid Solubility of Tin in Silicon

F. A. Trumbore, C. R. Isenberg, and **E. M. Porbansky,** Bell Telephone Labs., Inc., Murray Hill, N. J.

The distribution coefficient of Sn in Si, as determined by crystal pulling and thermal gradient crystallization techniques, falls from a value of 0.015 at the melting point of Si to a value of about 7×10^{-4} at lower temperatures. Resistivity and lifetime measurements indicate that Sn is electrically neutral in Si. The observed lattice parameter for crystals grown at 800°C is in agreement with the calculated lattice expansion assuming Vegard's law.

Abstract No. 43

A Sensitive Method of Measuring Optical Scattering in Silicon

G. H. Schwuttke, O. A. Weinreich, and **P. H. Keck,** Sylvania Electric Products Inc., Bayside, N. Y.

Radiation scattering in the high transparency infrared region of silicon can be utilized effectively to study the perfection of single crystals. A novel optical arrangement has been developed which is suitable for detecting extremely small amounts of scattered radiation. This method is sensitive enough to study minute inhomogeneities, e.g., fluctuations in concentration of impurities (oxygen).

Abstract No. 44

On the Crystal Chemistry of Semiconductors

E. Mooser and **W. B. Pearson,** National Research Council, Ottawa, Ont., Canada

On the basis of the valence bond theory a relationship is derived between the position in the Periodic Table of the chemical components of semiconductors and their crystal structures. Rules are given with which the coordination configurations in a semiconductor can be predicted with some certainty. We also examine the influence of the presence in the valence shell of empty *d* orbitals on the crystal structure and the results of this investigation are applied to the discussion of semiconductors containing groups VB to VIIB elements only.

Abstract No. 45

The Electronic Structure of Compounds Formed between Group VB to VIIB Elements

E. Mooser and **W. B. Pearson**, National Research Council, Ottawa, Ont., Canada

Crystal structures and properties of compounds of the types $A_2^{V}B_3^{VI}$ and $A^{V}B_3^{VII}$ are discussed on the basis of the valence bond theory of semiconductors. A consistent bond scheme is proposed for these substances and the band structures derived from it show some interesting features deviating, in many cases, from the usual semiconductor band structure. Thus, in Bi_2Te_3, for instance, it is found that the energy gap between valence and conduction band is bridged by a *d* band of low state density, the electrons in this band showing a low mobility. A series of new ternary semiconductors of the type $A^{V}B^{VI}C^{VII}$ is predicted.

Abstract No. 46

Semiconducting Compounds—A Challenge in Applied and Basic Research

A. C. Beer, Battelle Memorial Institute, Columbus, Ohio

The use of a number of semiconducting compounds in device applications are discussed for categories defined by the external field which produces a modulation of the carrier density or mobility. Included are applications based on response to electric fields, magnetic fields, thermal fields, photon energy, and thermal energy. The implications of

recent investigations as regards band structure, states densities, charge carrier mobilities, crystal imperfections, and other basic characteristics are presented.

Abstract No. 47

Recent Studies of the Properties of PbS, PbSe, and PbTe

W. W. Scanlon, U. S. Naval Ordnance Lab., White Oak, Md.

The solid phase of PbS is shown to exist only over a composition range from about 10^{19} excess sulfur atoms to 10^{19} excess lead atoms. Controlled composition within this range is discussed. Optical absorption edges in the three compounds have been established. Direct and indirect transition energies, radiative recombination rates, and radiative recombination lifetimes have been evaluated. The lifetime is shown to be limited by lattice recombination processes in PbS with the lifetime varing inversely within the concentration of dislocations.

Abstract No. 48

Interdiffusion by the Vacancy Mechanism in Binary Ionic Semiconductors

R. F. Brebrick, Naval Ordnance Lab., Silver Spring, Md.

Interdiffusion in a binary ionic semiconductor is considered starting from the phenomenological equations of Wagner. A consistent kinetic treatment of the vacancy mechanism establishes the composition dependence of the ion mobilities. Using chemical potentials recently given by the author, an expression for the complete composition dependence of the interdiffusion constant is derived. This expression agrees with the asymptotic values given by Wagner. The theory is applied to the available data on lead sulfide.

Abstract No. 49

Production of 1/f Noise by Radiation in Lead Sulfide Cells

R. L. Williams, Defense Research Board, Canadian Armament,

Research and Development Establishment, Quebec, Canada

The noise spectrum of a lead sulfide cell can be changed from one which is dominantly generation-recombination to 1/f by irradiating the cell with short wave-length radiation. The surface properties of lead sulfide along with the depth of penetration of short wave-length radiation are used to explain the effect. The change in spectral form can be produced at room temperature and dry ice temperatures. The experiments indicate that the use of the term "radiation noise" is too restrictive.

Abstract No. 50

Preparation of Crystals of Hexagonal SiC

D. R. Hamilton, Research Lab., Westinghouse Electric Corp., Pittsburgh 35, Pa.

Crystals of hexagonal SiC have been prepared by a method similar to that of Lely.* In particular, means of controlling crystal habit and nucleation have been introduced. Methods of preparation of relatively pure material are outlined, and some experiments on the growth of electroluminescent *p-n* junctions described. Some data are presented on the photoluminescence characteristics of a number of samples.

* J. A. Lely, *Ber. deut. keram. Ges.*, **32**, 229 (1955).

Abstract No. 51

High Pressure, High Temperature Growth of Cadmium Sulfide Crystals

W. E. Medcalf and R. H. Fahrig, Eagle-Picher Co., Miami, Okla.

A method was developed for growing cadmium sulfide crystals from the melt. Melting was carried out at pressures in excess of 100 atm and at temperatures greater than 1500°C. Single crystals weighing in excess of 100 g were grown. The crystals had desirable photovoltaic properties. High purity cadmium sulfide powder was produced by synthesis from elemental cadmium

and sulfur which had been purified by zone refining and other metallurgical techniques.

Abstract No. 52

Carrier Transport Phenomena in Semiconductor Crystals

E. M. Conwell, Sylvania Electric Products Inc., Bayside, N. Y.

This paper reviews some of the recent developments relating to carrier transport, mainly in Ge and Si. The dependence of lattice mobility on temperature and electric field intensity has been found to disagree with theory. Proposed explanations for the disagreement, as well as other effects of high electric field, are discussed. Properties peculiar to relatively impure samples and/or low temperatures, such as impurity band conduction and anomalously large thermoelectric power, are considered also.

Abstract No. 53

Electron Mobility in Indium Phosphide*

M. Glicksman and **K. Weiser,** RCA Labs., Princeton, N. J.

The Hall mobility of electrons in InP has been observed as a function of temperature and of carrier concentration. A lattice mobility of 5000 cm^2/v-sec at 290°K is calculated from these results, varing with temperature at least as rapidly as $T^{-2.1}$. The observations have been fitted by assuming a combination of lattice and ionized impurity scattering with an effective mass of the order of 0.05 m_o.

* This work was supported in part by the Air Force.

Abstract No. 54

Recombination of Carriers in InSb*

R. N. Zitter, A. J. Strauss, and **A. E. Attard,** Midway Labs., University of Chicago, Chicago, Ill.

* This research was supported by the U.S. Air Force, through the Office of Scientific Research of the Air Research and Development Command.

Recombination of excess carriers in n- and p-type InSb below 200°K is shown to take place primarily via bound states in the forbidden gap. Activation energies, concentrations, and recombination parameters associated with these states are estimated from measurements of the dependence of photoconductive and photoelectromagnetic lifetimes on temperature, impurity concentration, and light intensity.

Abstract No. 55

Avalanche Breakdown and Collector-Voltage-Saturation of Diffused Intrinsic Power Transistors

C. Huang, Sylvania Electric Products Inc., Woburn, Mass.

A theory is presented on the collector-voltage-saturation of a diffused intrinsic power transistor. Calculations are made for the distributions of carrier density, current density, and electrical potential in the emitter, base, and collector regions. The avalanche breakdown of this transistor is calculated based on Miller's data.* It is shown that a collector breakdown voltage of 1000 v is not incompatible with a saturation voltage of 1 v at a collector current of 10 amp.

* S. L. Miller, *Phys. Rev.*, 105, 1246 (1957).

Abstract No. 56

Effects of Radiation on Germanium and Silicon

G. C. Messenger and **J. P. Spratt,** Philco Corp., Philadelphia, Pa.

The effects of radiation-introduced defects on Ge and Si were obtained by irradiating transistors with neutrons from several different sources. The variation of transistor parameter with accumulated neutron dose shows that

$$\frac{1}{\tau_{eff}} = \frac{1}{\tau_{initial}} + \frac{\phi[\text{Neutrons/cm}^2]}{K}$$

	Lifetime damage constant K [neutrons/cm^2 $\times$ μ]
N Ge	$4.2 \pm 0.8 \times 10^{13}$
P Ge	$3.0 \pm 1.0 \times 10^{13}$
N Si	$1.1 \pm 0.4 \times 10^{13}$
P Si	$2.0 \pm 0.8 \times 10^{13}$

The recombination mechanism is of the Schottky-Read type with the important recombination site in *p*-Ge located 0.2 e.v. below the conduction band.

Abstract No. 57

Two New Transistor Switching Types

C. S. McCarthy, Jr., Philco Corp., Philadelphia, Pa.

This paper describes two new types of *P-N-P* Ge switching transistors. The first type is a symmetrically fabricated, homogeneous-base device, having large-area microalloy contacts. It is designed as a switch for core matrices in computer circuits. The second type (low-injection efficiency collector) was designed to minimize the minority-carrier storage time in the base region. This was accomplished by a surface-barrier-type collector. Pertinent design, fabrication, and performance data are presented.

Abstract No. 58

Factors Influencing Diffusion Processes

F. M. Smits, Bell Telephone Labs., Murray Hill, N. J.

Diffusion processes for the controlled introduction of impurities into semiconductors are determined by certain factors. A summary is given of these factors followed by a discussion of the experimental and theoretical knowledge about them. Included are the diffusion constant and its possible dependence on concentration, the effect of the initial conditions and the boundary conditions on the impurity distribution, and the role of undesirable impurities. Particular processes are mentioned only as representative for basic methods with emphasis placed on inherent advantages and limitations of such methods.

Abstract No. 59

Diffusion Concentration Profiles by Analog Computation

Worden Waring, Semiconductor Div., Raytheon Mfg. Co., Newton, Mass.

Use of an analog computer (REAC) to solve the diffusion equations gives solutions which take account of "out-diffusion" following initial "in-diffusion", "slumping" on reheating, and variation of the diffusion coefficient. The effects of such phenomena on junction locations and base widths of devices are found to be significant.

Abstract No. 60

Diffusion Control in Silicon by Carrier Gas Composition

C. J. Frosch and **L. Derick**, Bell Telephone Labs., Murray Hill, N. J.

A single heating process is described for producing controlled double diffused *n-p-n* structures in Si by changing the carrier gas type or composition during the diffusion. The process is shown to depend on the large changes in the volatility of compounds such as Ga_2O_3 at a given temperature in carrier gases of different type and composition. Data are presented for As_2O_5-Ga_2O_3 and Sb_2O_5-Ga_2O_3 diffusions to illustrate the control of layer thickness by heating first in wet N_2 and then in wet H_2. These diffused structures are shown to be suitable for the fabrication of high alpha transistors.

Abstract No. 61

Diffusion of Radioactive Antimony in Silicon

J. J. Rohan, **J. K. Kennedy**, and **N. E. Pickering**, Air Force Cambridge Research Center, Bedford, Mass.

Diffusion coefficients of Sb in Si obtained at several temperatures between 1200° and 1400°C are compared to values obtained via *p-n* junction techniques. A method is described for determining diffusion coefficients and surface concentrations from the integrated residual count rates of the 0.602 mev gamma of Sb-124, measured before and after removing successive 2-4 micron layers of Si perpendicular to the diffusion path. Low surface concentrations and relatively short anneal times minimize surface erosion.

Abstract No. 62

Diffusion into Silicon from Glassy Layers

J. E. Cline and **R. G. Seed**, Sylvania Electric Products Inc., Woburn, Mass.

The diffusion of boron into silicon from glassy layers containing the system K_2O-SiO_2-B_2O_3 was investigated. These glassy layers can be formed by dehydrating aqueous solutions; they are fluid at the diffusion temperature of 1200°C. Methods were developed for obtaining controllable initial concentrations and penetrations of diffusant. Uniformly flat junctions were obtained, apparently due to the solvent action of the glassy layers in preventing masking by silicon dioxide.

Abstract No. 63

Effects of Heat Treatment on Diffused Silicon Material

A. L. MacDonald and **W. J. Heinecke**, Raytheon Mfg. Co., Newton, Mass.

Two series of experiments are discussed which show the changes in bulk lifetime, resistivity, and diode characteristic as a function of heat treatment. All samples were heated at 1300°C for 20 hr. One series was cooled at a rate of 100°/hr to the desired temperature (1000°-300°C), and then quenched. The second series was quenched to the desired annealing temperature (700°-300°C) and the properties studied as a function of time. Attendant changes are presented.

Abstract No. 64

Semiconductor Surface Phenomena

A. Many, Sylvania Electric Products Inc., Bayside, N. Y. (On leave of absence from Hebrew University, Jerusalem, Israel)

This paper reviews recent results on the surface structure of semiconductors, especially Ge and Si, obtained from measurements of surface conductance, surface recombination velocity, field effect, etc. It is now well established that there are two distinct types of surface states referred to as slow and fast states. The characteristics of these

states, such as their distribution in energy in the forbidden gap and their hole or electron capture cross section, for different surfaces are summarized and discussed.

Abstract No. 65

Effects of Certain Chemical Treatments and Ambient Atmospheres on Surface Properties of Silicon

T. M. Buck and **F. S. McKim**, Bell Telephone Labs., Murray Hill, N. J.

Measurements of surface conductivity, recombination velocity (S), and field-effect mobility were made on Si. The choice of chemical treatments and ambient atmospheres made it possible to explore a wide range in surface potential and S. With the treatments used, low S occurs when the surface is either strongly *p*-type or strongly *n*-type; S is increased by atmospheres which shift surface potential in toward the middle from these extreme conditions.

Abstract No. 66

Effect of Various Etches on Recombination Centers at Germanium Surfaces

George Wallis and **Shyh Wang**, Sylvania Electric Products Inc., Woburn, Mass.

Germanium samples were etched with CP-4, hydrogen peroxide, iodine A, silver, and electrolytic etches. The density, energy levels, and capture probabilities of the surface recombination centers were measured before and after the etched samples were baked. Iodine A and electrolytic etch produce centers of type I; the remaining etches, centers of type II. On surfaces etched with iodine A, baking changes the type of centers to II. On surfaces etched otherwise, baking merely increases the density of the initial type of centers.

Abstract No. 67

Saturation Current in Germanium and Silicon Electrode

J. B. Flynn, Sylvania Electric Products Inc., Woburn, Mass.

The saturation currents observed in *n*-type Si and Ge anodes and *p*-type Si and Ge cathodes in certain aqueous electrolytic cells have been studied. With *n*-type Ge anodes in 1.35*N KOH*, the current is limited by bulk generation of carriers. *N*-type Si anodes in 5% HF shows that generation from the surface region is dominant. The cathodes (*p*-Si and Ge) show poorer saturation, but indicate contribution from surface generation.

Abstract No. 68

Theory of Electron Transfer Reactions at Semiconductor Electrodes

J. F. Dewald, Bell Telephone Labs., Murray Hill, N. J.

A general theory of electron transfer reactions at semiconductor electrodes is developed. Semiconductor electrodes are shown to differ from metal electrodes most importantly in (*a*) the ability of the electric fields to penetrate deep into the electrode, and (*b*) the existence of two, readily distinguishable kinds of electrons, i.e., valence and conduction band. Assuming nonradiative transitions, operation of the Franck-Condon principle and the absence of surface states, a relatively simple picture of the electron transfer processes is derived which gives the kinetic parameters for the hole and election currents in terms of the equilibrium properties of the electrode system.

Abstract No. 69

Experiments on Electron Transfer Reactions at the ZnO Electrode

J. F. Dewald, Bell Telephone Labs., Murray Hill, N. J.

Measurements of the kinetic parameters of several electron transfer reactions at single crystal zinc-oxide electrodes (*n*-type) are reported. Major dependences on semiconductor doping and on u.v. illumination are observed. The kinetics are similar in some respects to those observed on "valve" electrodes like Ta_2O_5, exhibiting strong dissymmetry between the anodic and cathodic processes. Interpretation of the data is made in terms of theory previously presented.

Abstract No. 70

Chemical Etching of Silicon, I. The System HF, HNO_3, N_2O

B. Schwartz and **H. Robbins**, Semiconductor Lab., Hughes Products, Los Angeles 45, Calif.

The kinetics of the dissolution of silicon in HF-HNO_3-H_2O solutions at 25°C are discussed. Experimental data cover the entire range of etching compositions which show measurable attack on a 111 silicon surface in a given time interval. Interpretation of the reaction mechanisms is discussed in relation to the data.

Abstract No. 71

Status of Semiconductor Process Technology

F. Biondi, Bell Telephone Labs., Murray Hill, N. J.

(No abstract received)

Abstract No. 72

On the Jet Etching of Germanium and Silicon

P. F. Schmidt and **D. A. Keiper**, Research Div., Philco Corp., Philadelphia, Pa.

The rate of jet-electropolishing of low resistivity *n*-Si is controlled by two factors: supply of injected minority carriers, and rate of dissolution of the SiO_2 film. On low resistivity *n*-Ge the applied electrostatic field can generate its own hole supply. Under certain conditions electropolishing is possible in complete darkness. Ge can also be jet-etched cathodically, the reaction product being GeH_4. This reaction does not take place on Si.

Abstract No. 73

Determination of Crystal Orientation by High Intensity Reflectograms

G. H. Schwuttke, Sylvania Electric Products Inc., Bayside, N. Y.

An instrument based on the light figure technique for optical orientation of Ge and Si is described which fulfills all requirements for a fast precision orientation of single crystals. The dependence of high intensity reflectograms on etching conditions is shown and standard etching specifications are given.

Abstract No. 74

Some Properties of Electroless Nickel Contacts to Silicon

Edwin Matovich, P. J. Heinle, and **J. E. McNamara,** Semiconductor Research Dept., Motorola, Inc., Phoenix, Ariz.

Electroless Ni contacts to Si were evaluated with respect to solderability, adherence, specific contact resistance, and ohmic character. These properties were investigated for *n*- and *p*-type Si having resistivities between 0.005 and 400 ohm-cm and various degrees of surface roughness. The effects on contact properties of plating in an ultrasonic bath and of annealing at temperatures up to 1000°C are discussed.

Abstract No. 75

The Use of Organo-Substituted Hydrolyzable Silanes on Silicon Devices

B. Schwartz, Semiconductor Lab., Hughes Products, Los Angeles, Calif.

Surface treating silicon devices with organo-substituted hydrolyzable silanes of the form R_{4-i} Si X_i (where R can be CH_3 C_6H_5, etc., and X can be Cl, OC_2H_5, and i = 1, 2, 3) results in improved characteristics of the device. Data are presented on the effect of "silaning" on reverse saturation current and channeling.

Abstract No. 76

Photolithographic Techniques as Applied to Semiconductor Devices

J. R. Nall and **J. W. Lathrop,** Diamond Ordnance Fuze Labs., Washington, D. C.

Techniques are described for the use of photosensitive coatings in the fabrication of semiconductor devices. The chemical, optical, thermal, and electrical characteristics of the coating are outlined and techniques of exposing and developing patterns are given. Application of photolithographic techniques to the specific problems of masking, vacuum deposition, electrodeposition, etching, and electrical insulation are discussed. Specific devices fabricated by photolithographic techniques are illustrated and their electrical characteristics presented.

ELECTROTHERMICS AND METALLURGY

Abstract No. 77

Review of Various Analytical Methods for Determination of Trace Impurities

L. Pepkowitz, Nuclear Materials and Equipment Co., Pittsburgh, Pa.

(No abstract received)

Abstract No. 78

Spectrochemical Methods for Analyzing High Purity Hafnium

T. A. Sullivan, R. W. Lewis, and **J. L. Potter,** Electrometallurgical Experimental Station, U. S. Bureau of Mines, Boulder City, Nev.

The Electrometallurgical Experiment Station of the United States Bureau of Mines at Boulder City, Nev., has been engaged in research for the production of high purity hafnium metal from off-grade hafnium sponge by electrolytic means. This paper deals with the spectrochemical methods developed for the analysis of this high purity metal. The metal is first converted to the oxide and the impurity elements are then determined spectrographically, using a silver chloride carrier technique.

Abstract No. 79

X-Ray Fluorescent Analysis of Tin in Titanium in the Range of 0.03-0.50% Tin

T. A. Sullivan, R. W. Lewis, and **L. Carpenter,** Electrometallurgical Experimental Station, U. S. Bureau of Mines, Boulder City, Nev.

The Analytical Laboratory of the Boulder City Station of the United States Bureau of Mines as a testing laboratory for compliance of titanium sponge to meet General Services Administration purchase specifications was faced with the problem of determining tin in titanium by a fast, accurate method. An x-ray fluorescent spectrographic method was developed, using the hardness button as a sample, that is both fast and accurate.

Abstract No. 80

Determination of Hydrogen in Titanium and Its Alloys—A Critical Review

T. D. McKinley, Research Div., Pigments Dept., E. I. du Pont de Nemours & Co., Inc., Experimental Station, Wilmington, Del.

Theory, operational characteristics, and indicated precision and accuracy of analytical methods based on vacuum extraction, equilibrium pressure, and combustion approaches are reviewed. At the present time vacuum extraction at 1400°C and the equilibrium pressure method are recommended for determination of hydrogen in titanium and titanium-rich alloys.

Abstract No. 81

Some Applications and Methods for Low Level Analysis of Specific Impurities in Metals

R. A. Wallace, T. G. Polanyi, and **John Roboz,** Central Research Labs., Sylvania Electric Products Inc., Bayside, N. Y.

Results on the mass-spectrometric analysis of tungsten and cathode nickel for potassium, and on silicon for boron, are presented. Data on preliminary work, using isotope-dilution techniques, are described. The relative ion yields for several chemical compound-surface ionizing systems were investigated in a single-filament surface ionization source. One system, at the relatively slow temperature of 650° ± 50°C, yields its major ionic species as singly charged, positive, elemental boron ions.

Abstract No. 82

Stress Corrosion Cracking of Austenitic Stainless Steels

J. J. Harwood, Office of Naval Research, Washington, D. C.

The factors influencing the susceptibility of austenitic stainless steels to stress corrosion cracking and the mechanisms which have been proposed are reviewed briefly. Environment, metallurgical structure, composition, temperature, time, surface condition, and stress are considered. General agreement exists about the conditions necessary to nucleate the

crack, but the mechanism by which the crack propagates remains to be resolved. Methods of prevention are discussed and recent findings indicate the benefits of composition and impurity control.

Abstract No. 83

Mechanism of Stress Corrosion of Type 304 Stainless Steel

H. L. Logan, National Bureau of Standards, Washington, D. C.

(No abstract received)

Abstract No. 84

Stress Corrosion Cracking of Some Homogeneous Alloys Containing Nickel

H. R. Copson, Research Lab., International Nickel Co., Inc., Bayonne, N. J.

The results of some laboratory tests on the stress corrosion cracking of Fe-Cr-Ni alloys, or Fe-Ni alloys, and of Ni-Cu alloys are described. In each of these systems susceptibility to stress corrosion cracking seems to be present when the atomic percentage of the more noble constituent is between 0 and 50%, with the maximum susceptibility occurring at some intermediate percentage. Some thoughts on mechanism are included. Presumably susceptible alloys resist cracking in many environments because crack initiation is prevented by protection films, by rapid uniform attack, or in some other way.

Abstract No. 85

Stress Corrosion of Austenitic Stainless Steel in High Temperature Water

M. G. Fontana, Ohio State University, Ohio

(No abstract received)

Abstract No. 86

Caustic Stress Corrosion of Type 347 Stainless Steel

G. C. Wheeler and **E. Howells,** Knolls Atomic Power Lab., Schenectady, N. Y.

Stress corrosion tests of Type 347 stainless steel were made in mixtures of caustic-in-water and caustic-in-sodium at temperatures be-

tween 488° and 850°F, using various types of specimens. Transgranular cracking of the specimens occurred in both solvents over a wide range of temperatures and concentrations. In miniature boiler tests, cracking was prevented by adding disodium phosphate to the boiler water at the rate of 1 part PO_4 to 4 parts caustic-anion.

Abstract No. 87

Cracking of Martensitic Stainless Steel under Conditions of Stress and Corrosion

B. F. Brown, Naval Research Lab., Washington, D. C.

(No abstract received)

Abstract No. 88

Paper voided

Abstract No. 89

Fused Salt Electrowinning and Electrorefining Methods

M. E. Sibert, Horizons Inc., 2891 E. 79 St., Cleveland, Ohio

A variety of metals which cannot be prepared by conventional smelting or aqueous reduction methods may be prepared in a high state of purity by fusion electrolysis. These include transition metals of Groups IV, V, and VI. Processing may be carried out by electrolytic decomposition of a metallic compound or by electrolytic refining of an impure metal through its employment as an anode. General process principles are described and illustrated. Advantages and limitations of these process types are discussed.

Abstract No. 90

Fused Salt Electrorefining of Hafnium Metal

D. H. Baker, Jr., J. R. Nettle, and **J. Heigel,** U. S. Bureau of Mines, Boulder City, Nev.

The U.S. Bureau of Mines Electrometallurgical Experiment Station at Boulder City, Nev., has, under the Atomic Energy Commis-

sion's sponsorship, attempted to apply the fused salt electrorefining techniques developed for titanium to off-grade hafnium sponge. This paper deals with the various electrolytes studied, and types and quality of deposits produced from these electrolytes. Hafnium metal with hardnesses as low as 130 BHN has been produced by this technique.

Abstract No. 91

Elemental High Purity Boron Preparation with Emphasis on Fused Salt Electrolytic Methods

E. W. Fajans, *et al.*, U. S. Borax and Chemical Corp., Anaheim, Calif.

(No abstract received)

Abstract No. 92

Fused Salt Electrorefining of Columbium Metal

E. C. Hirakis and **M. E. Sibert,** Horizons Inc., 2891 E. 79 St., Cleveland, Ohio

Attempts to purify crude columbium sponge by soluble anode electrolysis in fused salt electrolytes are described. Since small concentrations of oxygen are transported quantitatively to the cathode, the composition of the carbon reduced sponge is regulated so that a small excess of carbon is present. The crude anode material then contains a minimum of oxygen and a number of contaminants including carbon which are not transported electrolytically. The refined columbium is recovered as a crystalline powder.

Abstract No. 93

Paper voided

Abstract No. 94

The Hydrogen Reduction Method for the Preparation of High Purity Tungsten and Rhenium

C. H. Toensing, Lamp Wire & Phosphors Dept., Lamp Div., General Electric Co., 21800 Tungsten Rd., Cleveland 17, Ohio

A brief review of the historical aspects of hydrogen reduction ap-

plied to tungsten oxides with emphasis on purity as well as the chemical equilibra, the thermodynamic properties and the kinetics of the reduction reactions are presented. The application of these data to the commercial production of pure tungsten metal powders along with process variables are discussed. The technical methods currently employed to produce pure rhenium metal powder are reviewed.

Abstract No. 95

Aqueous Methods for the Preparation of High Purity Metals

G. B. Wood, National Bureau of Standards, Washington, D. C.

The preparation of high purity metals by electrorefining from aqueous solutions is discussed. Specific cases where metals of high purity have been obtained by electrodeposition are reviewed, such as Cu, Fe, Cr, Ni, Ag, Au, etc. Reference is made to high purity Al obtained from organic solutions.

Abstract No. 96

Preparation of Pure Chromium by a Vacuum Distillation Technique

W. H. Smith and **R. L. Hadley,** General Electric Co., Schenectady, N. Y., and Louisville, Ky., respectively.

Very high purity chromium was prepared by distillation in high vacuum. Alloys of Cr and Zr were prepared by arc melting, with Zr content ranging up to 10%. The Zr was added to tie up oxygen, nitrogen, sulfur, and carbon as nonvolatile impurities. During the evaporation of Cr from these alloys some reduction in metallic impurities was also effected. The Cr deposits obtained had an average hardness of 100 VPN. Most deposits were brittle at room temperature.

Abstract No. 97

Metallurgy of Uranium Refining

B. Blumenthal, Argonne National Lab, Lemont, Ill.

Metallurgical refining methods for uranium have been developed for three grades of uranium, each

one meeting a specific purpose: reactor grade uranium, irradiated uranium, and high purity uranium. The various refining methods—vacuum melting, liquidation, oxidation, carburization, formation of intermetallic compounds, molten metal and salt extraction, bomb reduction, vapor decomposition, and fused salt electrolysis—are evaluated with respect to the efficacy which each operation permits for the preparation of a pure product. The evaluation is based on thermodynamic considerations, experimental data, and practical factors.

Abstract No. 98

Phase Equilibrium Study of the System Na_2WO_4-Na_2CO_3-H_2O

R. L. Pilloton and **G. E. Crawley, Jr.**, Metals Research Labs., Electro Metallurgical Co., Division of Union Carbide Corp., Niagara Falls, N. Y.

A phase equilibrium diagram representing the binary system Na_2WO_4-H_2O between −7.5° and +35°C was constructed. This curve shows the regions of stability of the dihydrate and decahydrate of sodium tungstate. There is a eutectic ice-$Na_2WO_4 \cdot 10H_2O$ at −7.5°C, a transformation point $Na_2WO_4 \cdot 10H_2O$-$Na_2WO_4 \cdot 2H_2O$ at 6.2°C, and a metastable eutectic point ice-$Na_2WO_4 \cdot 2H_2O$ at −13°C.

Phase equilibria for the ternary system Na_2CO_3-Na_2WO_4-H_2O between −8° and +35°C are represented by a tridimensional diagram. Polythermal projections showing temperature contours and crystallization paths are given. The regions of stability of the various salts are presented. Applications of the diagram for fractional crystallizations are discussed.

Abstract No. 99

Methods for Preparing Pure Scandium Oxide

F. H. Spedding, J. E. Powell, A. H. Daane, M. A. Hiller, and **W. H. Adams,** Institute of Atomic Research, Iowa State College, Ames, Iowa.

A review of the techniques for isolating scandium in a pure state

is presented, including the newest cation-exchange methods. These methods include elution with ethlyenediaminetetraacetate and *N*-hydroxyethylethylenediaminetriacetate solutions and the use of copper and lead ions, respectively, as retaining ions which permit passage of scandium but retain rare earth ions. A new approach to opening thortveitite ore by treating with ammonium bifluoride and reducing the mixed metal fluorides to the metallic state with calcium is presented.

Abstract No. 100

On the Measurement of the Temperatures of Unenclosed Objects by Radiation Methods

A. Emslie and **H. Blau,** Arthur D. Little, Inc., Cambridge, Mass.

Both relative and absolute temperature measurement techniques that utilize emitted radiation are discussed and evaluated in terms of their application to the measurement of the temperature of nonplankian radiators. The accuracy of the various techniques is determined both under ideal and practical operating conditions. It is shown that accurate temperatures can be determined by using a two-color, two-temperature pyrometer without recourse to absolute measurement even when the spectral emissivity of the sample is unknown.

Abstract No. 101

Thermal Conductivity Measurement in the Temperature Range 1000°-3000°F

T. E. Waterman and **I. B. Fieldhouse,** Armour Research Foundation of Illinois Institute of Technology, Chicago, Ill.

A method is described for determining thermal conductivity of metallic and ceramic materials in the temperature range 1000°-3000°F. The method is one of unidirectional heat flow through a 6-¾ in. diameter, 1-½ in. thick disk of the material mounted between a heat source and a heat sink which also serves as a calorimeter. The rate of heat flow through the disk is obtained by collecting and weighing

the condensed vapor which results from the boiling of a liquid in the calorimeter. The energy required to produce boiling is transferred through the disk to the calorimeter from a Mo heater. Temperature measurements are made with Pt-Pt 10% Rh butt welded thermocouples. Since numerous investigators have measured the thermal conductivity of Armco iron and show good agreement, it was used to calibrate the equipment. As a result of this calibration, the accuracy of the results obtained by the method are believed to be within ±2%.

Abstract No. 102

Micro Furnace for Thermal Microscopy and Studies at High Temperatures

W. A. Lambertson and **G. Lewis,** Research and Development Div., The Carborundum Co., Niagara Falls, N. Y.

A small laboratory furnace is described for use in microscopy and for determining chemical compatibility, wetting, sintering, and temperatures of apparent melting up to 3000°C (5430°F). The furnace shell is a water-cooled, 5-in. copper tee and is of such construction as to afford a controlled atmosphere. Water-cooled electrodes are designed to hold refractory metal strip heaters (either plain or with a wedge for better black body conditions) or special machined graphite heaters. Stepless power input is provided by a variac-controlled, saturable core reactor.

Abstract No. 103

Water-Stabilized Arc Tests on Nonmetallic Materials

M. Dank, R. A. Nelson, W. R. Sheridan, and **W. H. Sutton,** Missiles and Ordnance Systems Dept., General Electric Co., Philadelphia, Pa.

Preliminary evaluation of erosion rates on possible high temperature resistant materials have been carried out in a water-stabilized arc. General classes of materials tested include: graphites and impregnated graphites; ceramics, principally oxides; plastic-ceramic com-

posites; and reinforced ceramics. Results on erosion rates as a function of power dissipated in the arc and time are given and a general ranking of these materials for high temperature use is discussed.

Abstract No. 104

Rigidity Relaxation in Recrystallized Tungsten Wires at Elevated Temperatures

I. Berlec, Lamp Development Dept., General Electric Co., Cleveland, Ohio

Rigidity relaxation of recrystallized tungsten filaments has been measured as a function of temperature and grain structure. Measurements were performed on various commercial grades of tungsten in the temperature range between 1000° and 3000°K. The apparatus is essentially a torsion pendulum operated in vacuum. The specimen under study is used as the suspension, and is heated by its own resistance.

Abstract No. 105

Strength of Titanium at 1300°-1600°C

E. Scala, Avco Corp., Lawrence, Mass.

Stress rupture data has been obtained for titanium at the nominal temperatures of 1300°, 1500°, and 1600°C. A linear relationship of log time vs. log stress was obtained for three different grades of unalloyed titanium; namely, RC-55 with 0.137% and 0.053% oxygen and Foote iodide titanium. The lower the original impurity content, the lower the stress rupture values. The slope of log time vs. log stress, however, remains essentially the same for all three grades of titanium at the three test temperatures. The equipment and techniques were established for operating creep and stress rupture tests at temperatures above 1500°C for materials affected by the absorption of oxygen, nitrogen, and carbon.

Abstract No. 106

The Activities of Refractory Metal Alloy Systems

Rudolph Speiser and George St. Pierre, Dept. of Metallurgical

Engrg., Ohio State University, Columbus, Ohio

Under favorable circumstances the activities of the components of refractory metal alloy systems can be ascertained from the composition of the vapor effusing from the Knudsen cell containing the alloy. It can be shown that the absolute partial pressures need not be determined if sufficient experimental data are obtained to make a satisfactory extrapolation of the data to the pure component. This method can be used to determine the phase diagram of an n-ary alloy system.

Abstract No. 107

Vapor Pressure of Columbium

Rudolph Speiser, Dept. of Metallurgical Engrg., Ohio State University, Columbus, Ohio, **Paul Blackburn,** Westinghouse Research Lab., Pittsburgh, Pa., and **Herrick Johnston,** Herrick Johnston Associates, Columbus, Ohio

(No abstract received)

Abstract No. 108

Contributions of Zone Melting to High Purity Materials

F. H. Horn, Research Lab., General Electric Co., Schenectady, N. Y.

(No abstract received)

Abstract No. 109

Application of the Floating Zone Technique to Metals

R. L. Smith, J. L. Rutherford, and **M. Herman,** The Franklin Institute Labs. for Research and Development, Philadelphia 3, Pa.

The application of the floating zone method of purification to some crucible reactive metals is discussed. The use of RF melting in which the induction coil is placed either inside or outside of the protecting envelope is described. The advantages and disadvantages of purifying in a reducing or in an inert atmosphere and in a vacuum are discussed. The results of some mechanical properties of zone refined Fe, Ti, and Zr are presented.

Abstract No. 110

Tungsten Zone Melting by Electron Bombardment

R. G. Carlson, General Electric Co., Cleveland, Ohio

An apparatus for refining tungsten by the floating zone method is described. It consists of four components: vacuum system, power supply, cathode traversal assembly, and anode support. Power requirements for melting ⅛ in. diameter rods are found to be in the order of 500 w. As many as ten passes at different rates of travel have been made. Tungsten rods that are refined by this techique have relatively high ductility at room temperature, as determined by tensile and bend tests, and are of very high purity.

Abstract No. 111

Techniques and Results of Zone Refining Some Metals and Semiconducting Compounds

J. H. Wernick, K. E. Benson, D. Dorsi, and **J. J. Gillich,** Bell Telephone Labs., Inc., Murray Hill, N. J.

Techniques and results for zone refining Ag, Al, Sb, Au, Cu, Ni, Ti, V, and ternary semiconducting compounds are given. Boat and floating zone methods are discussed.

Abstract No. 112

Continuous Multistage Zone Melting of Silicon Tetraiodide

G. H. Moates and **B. Rubin,** Air Force Cambridge Research Center, Bedford, Mass.

A continuous multistage apparatus which separates purified and impurity-enriched silicon tetraiodide into separate receivers has been constructed. The continuous operation of this apparatus is based on the introduction of voids which travel the length of the enriching and stripping arms and which are filled in as they reach a reservoir. The design characteristics are based on the segregation coefficients of the impurities in the silicon tetraiodide, the length of the molten zones, the length of the voids, and the length of the arms.

Abstract No. 113

Principles and Application of the Iodide Process

A. C. Loonam, 70 E. 45th St., New York 17, N. Y.

The origin of the process, its development, and the elements to which it has been applied are reviewed; some of the fundamentals and methods of operation are discussed.

Abstract No. 114

The Iodide Process for High Purity Silicon Preparation

F. B. Litton, Research and Development Labs., Foote Mineral Co., Berwyn, Pa.

(No abstract received)

Abstract No. 115

Some Aspects of the Decomposition of Silicon Tetraiodide

A. F. Armington and **B. Rubin,** Air Force Cambridge Research Center, Bedford, Mass.

Silicon tetraiodide has been decomposed to silicon and iodine *in vacuo* with deposition on a single-crystal silicon substrate heated inductively. Effects of rate of passage of the vapor, vapor pressure of the iodide, and temperature of the substrate have been studied and results have been correlated with yield of silicon and rate of deposition.

Abstract No. 116

Zirconium Coating of Uranium by the Iodide Process

W. L. Robb, Knolls Atomic Power Laboratory, Schenectady, N. Y. (Present address: Research Lab., General Electric Co., Schenectady, N. Y.)

A method for coating uranium metal with a bonded layer of crystalline zirconium metal has been developed. It consists of thermally decomposing ZrI_4 vapors on the surface of uranium metal heated to about 1100°C in a good vacuum. Prior to coating, the uranium metal surface is cleaned by iodiding it. In this way a diffusion bond between the uranium and zirconium is obtained. Several methods for im-

proving the bond and reducing the porosity of the crystalline zirconium coating are also reported.

Abstract No. 117

High Purity Silicon from Silicon Tetraiodide Purified by Solvent Recrystallization and Distillation

L. V. McCarty, Lamp Development Dept., General Electric Co., Cleveland, Ohio

This paper deals with the electrical properties of silicon prepared from silicon tetraiodide purified by recrystallization from solvents, by distillation in an all-quartz column, and by a combination of the two techniques. The silicon was deposited on hot tantalum or quartz at reduced pressure, and single crystals were prepared in quartz crucibles. Portions of the better samples have resistivities which correspond to a minimum of five to seventeen boron atoms per ten billion silicon atoms.

Abstract No. 118

Plating of Tungsten with Titanium and Zirconium by the Van Arkel-de Boer Process

H. T. Stephenson, Strong-Cobb Co., Cleveland, Ohio

(No abstract received)

Abstract No. 119

High Purity Crystalline Boron

D. R. Stern and **Lahmer Lynds,** American Potash & Chemical Corp., Whittier, Calif.

Vapor phase reduction of boron trichloride with hydrogen on electrically heated filaments in flow systems was investigated as a potential method for the preparation of high purity boron. Massive deposits of crystalline boron analyzing as high as 99.6% by direct chemical analyses were obtained. Purity of boron appeared to be a function of both filament diffusion and boron trichloride purity. Titanium filaments were found to be most satisfactory, since contamination due to titanium could be removed by chlorination at 300°C. X-ray diffrac-

tion studies indicated that titanium existed in solid solution with boron rather than as a boride.

INDUSTRIAL ELECTROLYTIC

Abstract No. 120

Electrodeposition of Adherent Titanium Coatings on Induction Heated Cathodes in Fused Salts

J. G. Wurm, B. J. Fortin, L. Gravel, and **R. J. A. Potvin,** Laval University, Quebec, Que., Canada

A new electrolytic method for the deposition of adherent coatings of titanium on steel cathodes is described. The procedure involves the use of fused alkali-halide baths composed of eutectic mixtures of lithium, potassium or sodium iodides, bromides, chlorides, and fluorides, with a high frequency heated cathode and a soluble titanium anode. The bath composed of KI-KF performed best and deposited a very smooth and uniform titanium coating. Conversely, the bath composed of KI-NaI and TiI_4 (2-5%) yielded pure dendritic Ti and is therefore considered more suitable for an electrorefining process. Equipment and operating conditions are described and the microstructure of the coating produced is reported. A series of decomposition voltage curves are included and discussed, and the mechanism of the electrolytic reactions is studied in detail.

Abstract No. 121

Refining of Titanium Scrap by Fluoride Electrolysis

S. S. Carlton and **B. C. Raynes,** Horizons Inc., Cleveland 4, Ohio

The electrolytic recovery and purification of unalloyed titanium scrap by a semicontinuous operation is described. The process employs titanium scrap or off-grade primary metal as the soluble anode in an electrolytic cell containing a fused electrolyte of K_2TiF_6 in NaCl. Interstitial and metallic impurities remain as an inactive sludge and refined titanium is cathodically deposited as crystalline powder. Re-

fined titanium with as-cast hardness of 80 Brinell has been produced in a pilot operation carried out at Horizons Inc.

Abstract No. 122

Report of the Chlor-Alkali Committee of the Industrial Electrolytic Division for the Year 1957

J. C. Cole, Diamond Alkali Co., Cleveland, Ohio, and **R. B. MacMullin,** R. B. MacMullin Associates, Niagara Falls, N. Y.

Production facilities for chlorine and alkali are reviewed with indications of market and end use patterns. New plants and expansions during the year and technical and outstanding commercial developments are noted.

Abstract No. 123

Effect of Gas Evolution on Current Distribution and Cell Resistance

C. W. Tobias, Dept. of Chemical Engrg., University of California, Berkeley, Calif.

It is known that when gaseous products are liberated at one or both electrodes of an electrolytic cell the effective resistance of electrolyte is larger than in the gas-free cell, and the volume concentration of gas generally increases in the direction of flow of gas. The resulting variation in effective conductance can cause nonuniform distribution of current density. Using a simple parallel vertical electrode arrangement as a model, theoretical predictions are made for gas holdup in the cell and current distribution along the electrodes.

Abstract No. 124

Investigations on the Structure of the Color Compound in Caustic

S. Wawzonek and **D. S. P. Eftax,** Dept. of Chemistry, State University of Iowa, Iowa City, Iowa

The material isolated by Heller from stubs of graphite anodes used in chlorine-caustic soda cells and shown by him to give the color in concentrated caustic soda has been reinvestigated. An extract from the stubs after treatment with nitric acid was found to consist of mellitic acid, pentacarboxychlorobenzene, a

tetracarboxychlorobenzene of unknown configuration, and material of unknown structure which is the source of the color. The acids were formed during the treatment with nitric acid. The color forming material seems to be of high molecular weight and structurally more complex than proposed by Heller.

THEORETICAL ELECTROCHEMISTRY

Abstract No. 125

Relative Rates of Electromigration of Different Ions of the Same Charge across Permselective Membranes

Rex Neihof, Ruth McClintock, and **Karl Sollner,** Lab. of Physical Biology, National Institute of Arthritis and Metabolic Diseases, National Institutes of Health, Public Health Service, Bethesda, Md.

The theory of polyionic potentials permits the prediction of the ratios of the rates of electromigration across permselective membranes of any two species of critical ions coexisting in solution. These ratios are calculated from the bi-ionic potentials arising with the same pair of ions across the same membrane. This prediction was approximately confirmed in experiments with various combinations of critical ions in systems with cation selective and with anion selective membranes.

Abstract No. 126

Improved Protamine Collodion Membranes of Extreme Ionic Selectivity

Marc Lewis and **Karl Sollner,** Lab. of Physical Biology, National Institute of Arthritic and Metabolic Diseases, National Institutes of Health, Public Health Service, Bethesda, Md.

The use of purified protamine makes possible the preparation of permselective protamine collodion membranes of extreme ionic selectivity, the anion permeabilities in 0.1*N* KCl being 300-500 times greater than the cation permeabilities, and 4,000-11,000 times greater

in 0.01*N* solution. Concentration potentials across these membranes agree with the calculated maximum potentials in potassium chloride cells up to 0.1*N*/0.05*N* within the meaningfulness of the method.

Abstract No. 127

Transport Processes in Ionic Membranes

K. S. Spiegler, Gulf Research & Development Co., Pittsburgh, Pa.

A simple molecular model representing an ion-exchange membrane in equilibrium with a salt solution is described. The transport processes caused by pressure, electrical, and osmotic forces are computed in terms of the volume concentrations of ions, water, and solid, and certain "friction coefficients" between these components. This analysis suggests approximations which reduce the number of the experiments needed for describing the transport properties of the membrane. Some applications of the theory are illustrated.

Abstract No. 128

Transport in Ion-Selective Membranes

M. A. Peterson and **H. P. Gregor,** Dept. of Chemistry, Polytechnic Institute of Brooklyn, Brooklyn, N. Y.

The exchange and transport of gegenions and of nebenions (excluded ions) in ion-selective membranes was measured as a function of the solution phase concentration, stirring at the membrane interface, and applied current density. From these results the thickness of the unstirred film and diffusion coefficients of ionic species were calculated. The boundary conditions which define film, membrane, or coupled film-membrane transport mechanisms as being rate controlling were determined.

Abstract No. 129

Transport against the Chemical or Electrochemical Gradient in Charged Porous Membranes

Richard Schlögl, Max-Planck-Institut für Physikalische Chemie, Bunsenstr. 10, Goettingen, Germany

Investigations on membranes of ion exchange material have shown that the essential types of transport mechanism are: diffusion, convection, and electrical transference. A quantitative treatment of a simple membrane model confirms the empirical laws governing negative and anomalous positive osmosis. It is also possible to construct a working model based on these three mechanisms which imitates the concentration of K^+ and dilution of Na^+ in living cells compared with the surrounding body fluid. The source of free energy required for this stationary state of non-equilibrium is the continuous production of an acid within the cell.

Abstract No. 130

Membrane Potentials in Isothermal and Nonisothermal Systems; A Detailed Investigation of a Single Membrane System

G. J. Hills and **P. W. M. Jacobs**, Dept. of Chemistry, Imperial College of Science and Technology, Imperial Institute Rd., London, S. W. 7, England

Results are presented of measurements of a number of interrelated properties of a single membrane system, cross-linked polymethacrylic acid. The properties include ionic and solvent transport numbers, isothermal and nonisothermal membrane potentials, ionic self-diffusion coefficients, and ionic conductances for a number of alkali metal counter-ions. These observations are correlated and interpreted in terms of both classical theory and the thermodynamics of irreversible processes.

Abstract No. 131

Electro-Osmosis and Electro-Convection in Ionic Membranes; Relation between Electro-Osmotic Transport, Ionic Conduction, Ionic Self-Diffusion, and the Degree of Counter-Ion Solvation

G. J. Hills and **P. W. M. Jacobs**, Dept. of Chemistry, Imperial College of Science and Technology, Imperial Institute Rd., London, S.W. 7, England

Accurate measurements of the electro-osmotic transport through a

number of membranes have been made as a function of ion-type and of current density. The limiting equivalent electro-osmotic flow is discussed in terms of the difference between the two derived mobilities and the probable degree of counter-ion solvation.

Abstract No. 132

Phenomenological Electrochemistry of Membranes

George Scatchard, Massachusetts Institute of Technology, Cambridge 39, Mass.

The electrochemical study of membranes, particularly of physiological membranes, has been seriously hampered by the use of unrealistic models such as right-circular-cylindrical pores. An important contribution of the thermodynamics of irreversible processes is to show what parameters can be determined and which measurements are most suitable for determining them. To be useful the description must be simple. Most living membranes must be studied through over-all transport properties. Synthetic membranes may serve as models for which detailed mapping is possible.

Abstract No. 133

Streaming Potentials of Corundum in Organic Electrolyte Solutions

H. J. Modi and **D. W. Fuerstenau,** Dept. of Metallurgy, Massachusetts Institute of Technology, Cambridge, Mass.

The effect of certain 12-carbon anionic and cationic surface-active compounds on the zeta potential of corundum at different pH values has been evaluated from streaming potential measurements. These measurements, made under conditions of both positive and negative surface charge, indicate that long-chained ions are adsorbed appreciably only when the solid and organic ions are oppositely charged. An adsorption mechanism involving electrostatic attraction and hydrocarbon chain association is discussed.

Abstract No. 134

Interpretations of Experimental Donnan Equilibria Obtained with Polyphosphates

U. P. Strauss, School of Chemistry, Rutgers, The State University, New Brunswick, N. J.

The distribution of electrolyte across a semipermeable membrane has been measured for long-chain polyphosphates in aqueous solutions of lithium, sodium, potassium, and tetramethylammonium bromide. The conventional interpretation of the results in terms of an effective degree of ionization, α, leads to an increase of α with increasing electrolyte concentration. A more satisfactory interpretation is obtained by considering the Donnan equilibrium as arising from the volume excluded by the polyelectrolyte.

Abstract No. 135

Direct Determination of Adsorption of Organic Molecules at Solid Electrodes

B. E. Conway and **R. G. Barradas**, University of Ottawa, Ottawa 2, Canada

The necessity for development of a thermodynamically rigorous method for determination of adsorption of ions and molecules at *solid* electrodes is stressed. For molecules which absorb in a convenient spectral region, adsorption may be followed directly under thermodynamically reversible conditions at solid electrodes in a cell in which absorbance and potential measurements are made simultaneously. Results obtained with benzacridine, acridine, quinoline, pyridine, poly-4-vinyl pyridine, and their quaternary ions at Ag, Cu, and Ni, electrodes are described.

Abstract No. 136

Electrokinetic Measurements on Stainless Steel Capillaries

B. Levy and **A. R. Fritsch**, Radiation & Nucleonics Lab., Materials Engineering Dept., Westinghouse Electric Corp., East Pittsburgh, Pa.

Electrokinetic potentials of stainless steel in HCl, H_2SO_4, and $K_2Cr_2O_7$

solutions have been measured by the streaming current technique. Negative zeta potentials are obtained in H_2O and in low acid concentrations. The isoelectric acid concentrations occur between 10^{-4} and $10^{-5}N$. At higher concentrations positive potentials are obtained. $K_2Cr_2O_7$ adsorbs irreversibly at its isoelectric concentration of $10^{-5}M$ as evidenced by the inability of water washing to return the sample to its original negative zeta potential.

Abstract No. 137

Surface Conductance of Clays

H. van Olphen, Exploration and Production Research Div., Shell Development Co., 3737 Bellaire Blvd., Houston 25, Texas

On the basis of a particle network picture, the specific surface conductance of a clay may be calculated from the conductance of the clay gel. Since the charge density is known, the ion mobility parallel to the surface may be calculated. From particle interaction studies, it has been concluded that the counter ions are strongly adsorbed. Nevertheless, the surface mobility of the ions is relatively high, indicating a small barrier for lateral movement of the ions.

Abstract No. 138

Membrane Phenomena in Applied Geophysics

M. Gondouin, Schlumberger Well Surveying Corp., Ridgefield, Conn.

Natural membrane potentials and electrokinetic phenomena play an important role in oil exploration. These potentials observed in wells filled with mud result from the ion exchange properties of clays in shales and muds. From laboratory results an approximate expression for the shale membrane potential with mixed electrolytes is derived using simplifying assumptions. Data on shale electrokinetic properties are given and related to ionic transport numbers. Dependence of shale conductivity on frequency and polarization effects are discussed.

Abstract No. 139

Influence of Firing Conditions, Composition, and Screening Media on the Zeta Potentials of ZnS Phosphors as Related to Adherence to Glass Surfaces

B. Levy, Electron Tube Div., Radio Corporation of America, Lancaster, Pa. (Present Address: Radiation and Nucleonics Lab., Materials Engrg. Dept., Westinghouse Electric Corp., East Pittsburgh, Pa.)

Zeta potentials of ZnS phosphors were determined by the streaming potential technique as a function of firing conditions, flux, activation, phosphor coating, and type and concentration of screening media. Either positive or negative potentials are obtained depending on the type of coating. Certain firing conditions change the sign of the zeta potential. In all of these experiments a trend toward enhanced wet adherence with decreasing negative and increasing positive zeta potentials has been noted.

Abstract No. 140

The Electrokinetic Potential and Some Surface Tension Phenomena

L. B. Robinson, Ramo-Wooldridge Corp., P.O. Box 45144 Airport Station, Los Angeles 45, Calif.

The Onsager-Samaras theory (without adjustable constants) allows one to calculate the surface tension of an aqueous electrolyte solution as a function of concentration. It predicts that an electrolyte added to water would increase the surface tension. Precise measurements of the surface tension by the capillary rise method give an initial decrease and a minimum in the surface tension-concentration wave. Theory and experiment can be reconciled by taking the electrokinetic effects into account.

Abstract No. 141

Overvoltage and Catalysis

Paul Ruetschi, Research Dept., The Electric Storage Battery Co., Philadelphia, Pa.

Rate equations describing the kinetics of electrode reactions have hitherto been formulated without taking into account the activity of

intermediate species on the electrode surface. The interaction of adsorbed species is shown to be of importance on overvoltage characteristics. Adsorbed species induce a contact potential change proportional to their concentration which is accompanied by a corresponding change in adsorption energy. The meaning of exchange currents is discussed and the rate equations are reformulated. The electronic or catalytic properties of the electrode material are reflected in these rate equations.

Abstract No. 142

Cathodic and Anodic Properties of Chlorine on Carbon and Graphite Surfaces*

John Aylward, Ernest Yeager, and **Frank Hovorka,** Dept. of Chemistry, Western Reserve University, Cleveland, Ohio

The cathodic and anodic polarization of the chlorine electrode have been measured on graphite and carbon surfaces in HCl solutions saturated with chlorine gas. Mechanisms for the anodic and cathodic processes are proposed on the basis of the experimentally determined Tafel slopes and the stoichiometric number calculated from polarization measurements at low current densities. The mechanism of the anodic process appears to be complex as indicated by a change in the Tafel slope with changing HCl concentration.

* Research supported by the Office of Naval Research under Contract Nonr 581(00).

Abstract No. 143

Electrode Potentials of Titanium-Oxygen Alloys

R. S. Dean, I. Hornstein, and **W. W. Gullett,** Chicago Development Corp., Riverdale, Md.

The value of electrode potentials of titanium-oxygen alloys as measured against standard titanium samples in molten salt electrolytes have a definite relation to the oxygen content of the alloy. The smooth relationship between emf and oxygen content in the beta phase indicates that the technique may be used to determine oxygen contents of alloys containing less than 0.15%

oxygen. The effects of alloying elements and impurities on the emf measurements have also been investigated.

Abstract No. 144

Mechanisms of Hydrogen-Producing Reactions on Palladium, V. The Deuterium-Palladium System

Sigmund Schuldiner and **J. P. Hoare**, Naval Research Laboratory, Washington, D. C.

Anodic and cathodic polarization curves for the α-D-Pd system were determined on a Pd bi-electrode. The experimental equilibrium potential of the $(Pd\text{-}D)_\alpha/D^+$ electrode was found to be 0.029 ± 0.001 v. The rate $(-di/d\eta)$ of the over-all deuterium-producing reaction on an α-Pd-D electrode surface in the linear η vs. i region was found to be about one-half that of the hydrogen-producing reaction on α-Pd-H. At constant overvoltage, the rate of diffusion of hydrogen through the bi-electrode ranged from 2.2 to 1.06 times faster than deuterium, depending on the polarizing current density. It was also found that at low current densities 90% of the deuterium formed on the cathode side diffused through the bi-electrode and was ionized on the anode side.

For a β-deuterium-palladium cathode-diaphragm, it was shown that the reaction mechanisms were the same as for a β-hydrogen-palladium diaphragm. A calculation was made which showed that, at a given atomic concentration gradient, the rate of diffusion of hydrogen through a β-Pd diaphragm was $2^{1/2}$ times faster than that of deuterium.

Abstract No. 145

Double Layer Structure and Electrode Processes, I. Salt Effect

Manfred Breiter, Marcos Kleinerman, and **Paul Delahay**, Dept. of Chemistry, Louisiana State University, Baton Rouge, La.

Ideas originally advanced by Frumkin and co-workers on the effect of the double layer structure on electrode processes are applied and extended to the following problems: (*a*) influence of foreign salts on the exchange current for slow

and fast reactions; (*b*) complications resulting from control of ionic strength rather than ionic charges; (*c*) possible error in the determination of transfer coefficients for reactions occurring near the point of zero charge. Detailed experimental results are presented.

Abstract No. 146

Double Layer Structure and Electrode Processes, II. Discharge of Certain Metallic Complexes

Paul Delahay and **Carl Weis,** Dept. of Chemistry, Louisiana State University, Baton Rouge, La.

Experimental determination of kinetic data by electrochemical relaxation methods for chemical reactions coupled with electrochemical reactions is affected by the double layer structure when ions having charges of the same sign are involved. Correction can be made when the chemical reaction occurs essentially in a layer which is appreciably thinner than the diffuse double layer. The effect of foreign salts on kinetic data can then be interpreted quantitatively. Experimental data are presented for the study of the reduction of several complexes by the current-step (galvanostatic) method.

Abstract No. 147

Schlieren Studies of Concentration Gradients at a Cu/HCl Anode

R. S. Cooper, University of Illinois, Urbana, Ill. (Present Address: University of California, Los Alamos Scientific Lab., Los Alamos, N. Mex.).

Schlieren optical techniques were applied to the study of the anolyte at a Cu/HCl anode during current transients. Both the space and time dependence of the concentration gradients were observed quantitatively and correlated to the electrochemical processes occurring at the anode. The development and relative importance of ionic diffusion and natural as means of mass transport was studied under various conditions.

Abstract No. 148

The Nature of the Current Flow at or Between Cylindrical Electrodes*

R. D. Barnard and **S. M. Skinner**, Case Institute of Technology, Cleveland 6, Ohio

Solid-state thermodynamic equations of electrical current flow of the majority carrier in nonmetallic materials are solved in cylindrical coordinates for the case in which external potential is applied to the electrodes. Current, charge transfer at boundary, and inner potential are dependent both on the nature and separation of electrodes and on the electrode curvature. Current is nonlinear with voltage, and rectification is possible. Mechanical and electrical quantities related to the current are considered.

* With the support of the Office of Ordnance Research.

Abstract No. 149

Electromotive Force Measurements in Cerium-Cerium Chloride Liquid Systems

S. Senderoff and **G. W. Mellors**, Chemistry Div., Research Labs., National Carbon Corp., A Division of Union Carbide Corp., P.O. Box 6116, Cleveland 1, Ohio

The emf of the cell $Ce|CeCl_3(1\text{-}x)\,Ce(x)||CeCl_4|Cl_2$ (graphite) has been measured over a temperature range from the melting point of $CeCl_3$ to about 950°C. Preliminary conductance measurements indicate that the saturated solution of cerium in cerium chloride is an ionic conductor. The potential results indicate the presence of a subhalide, $Ce^+[CeCl_4]^-$, in which both monovalent and trivalent cerium exist. Further, it is suggested that cerium chloride may exist in a highly associated state in which the following formula may represent the dominant species, viz., $[CeCl_3]^+[CeCl_4]^-$. The addition of cerium to this system may result in the reduction of the less highly complexed cation as follows:

$$[Ce^{4+}Cl_3]^+\,[Ce^{3+}Cl_4]^- + Ce \rightarrow 3/2\;\; Ce^+\,[Ce^{3+}Cl_4]^-$$

In the course of the work a reversible chlorine electrode, satisfac-

tory at temperatures up to 950°C, was developed.

Abstract No. 150

Activities of $NiCl_2$ from EMF Measurements in Molten LiCl-KCl

R. D. Walker, Jr., and **D. E. Danly,** Dept. of Chemical Engrg., University of Florida, Gainesville, Fla.

Activities of $NiCl_2$ dissolved in fused LiCl-KCl have been estimated from emf measurements in the temperature range 500°-700°C. Activity coefficients based on a standard state of pure liquid $NiCl_2$ increase with both temperature and solute concentration, and indicate strong complexing of $NiCl_2$. Emf and x-ray evidence indicate that the solid separating from a melt of LiCl-KCl-$NiCl_2$ differs from the original components; the compound K_2NiCl_4 is postulated.

Abstract No. 151

Electropolishing Silicon in Hydrofluoric Acid Solutions

D. R. Turner, Bell Telephone Labs., Inc., Murray Hill, N. J.

Silicon is electropolished in HF solutions if a critical current density is exceeded. Below the critical c.d., Si dissolution is largely divalent and a thick solid layer forms. This film is unstable and reacts slowly with the electrolyte to form tetravalent Si and H_2. In the electropolishing region, Si dissolution is mainly tetravalent with the formation of a very thin high resistance type of film. Experimental results on the effect of HF concentration and temperature indicate that electropolishing begins when the HF concentration at the Si becomes diffusion limited.

Abstract No. 152

Thermodynamics of Electron Atmospheres at Interfaces*

S. M. Skinner, Case Institute of Technology, Cleveland 6, Ohio

The thermodynamics of the final charge equilibrium at the interface between two different materials is discussed in terms of the chemical and electrical properties

of the materials. The kinetics of the attainment of equilibrium is developed, and a number of practical applications are treated in detail, including the charging of dielectric and polymer surfaces, destaticization, and charge transfer during frictional sliding contact.

* With the support of the Office of Ordnance Research.

Abstract No. 153

Codeposition of Nickel and Hydrogen from Simple Aqueous Solutions

John Yeager, (Present address: National Carbon Research Labs. Parma Ohio), **J. P. Cels,** (Present address: The Kemet Co., Cleveland, Ohio), **Ernest Yeager,** and **Frank Hovorka,** Dept. of Chemistry, Western Reserve University, Cleveland, Ohio

The codeposition of nickel and hydrogen has been studied in chloride and sulfate solutions and the individual polarization curves determined. Nickel polarization has a Tafel slope of 0.10 and is independent of pH and anion type at constant nickel ion activity. Hydrogen overvoltage at constant pH is independent of anion type with a Tafel slope of 0.12. Hydrogen and nickel deposition exhibit no appreciable interdependence. Nickel polarization data are explained in terms of the transfer of a nickel ion from the solution across an unsymmetrical potential energy barrier to the metal phase.

Abstract No. 154

Effect of Addition Agents on Tungsten Codeposition

J. S. Sallo and **R. D. Fisher,** Research Div., National Cash Register Co., Dayton 9, Ohio

Trace amounts of certain compounds containing the C-S functional group prevent the codeposition of tungsten with Fe, Ni, or Co. Results indicate that the addition agents act through a complexation mechanism. The structure of the nickel-tungsten deposit, as determined by x-ray diffraction, does not agree with the structure predicted by the catalytic reduction mechanism of codeposition. Both the

x-ray data and the prevention of codeposition can be explained by either a complexation mechanism of codeposition or by a modified form of the catalytic reduction mechanism.

Abstract No. 155

Anodic Oxidation of Zinc and a Method of Altering the Characteristics of the Anodic Films

H. Fry and **Marjorie Whitaker,** British Non-Ferrous Metals Research Assoc., Euston St., London N. W. 1, England

Preliminary work on anodizing zinc in a variety of alkaline solutions led to some smooth white or gray films. A detailed study was made of the anodic oxidation of zinc and zinc alloys in one electrolyte, the results of which suggest similarities but also some differences between anodic films on Al and on Zn. Autoclaving in silicate solutions improved the resistance to corrosion and abrasion and changed the chemical composition of the anodic films without altering their appearance greatly.

Abstract No. 156

Anodic Dissolution of Magnesium in Aqueous Solution

Richard Glicksman, RCA Labs., Princeton, N. J.

(No abstract received)

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FALL MEETING

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September 28, 29, 30, and
October 1 and 2, 1958

Sessions probably will be scheduled on

Batteries
Corrosion
Electrodeposition (including symposia on "Electrodeposition on Uncommon Metals" and "Chemical and Electropolishing")

Electronics—Semiconductors
Electro-Organics
Electrothermics and Metallurgy
and a symposium on "Films Formed in Contact with Liquids" sponsored by Theoretical Electrochemistry, Battery, and Corrosion Divisions

Abstracts for the Fall Meeting (*not exceeding 75 words in length*) must reach the Secretary's Office, 1860 Broadway, New York 23, N. Y., *not later than June 2, 1958* in order to be included in the program.

Indicate on abstract for which Division's symposium the paper is to be scheduled.

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